PRELIMINARY REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY

OF

WYOMING,

AND

PORTIONS OF CONTIGUOUS TERRITORIES,

(BEING A SECOND ANNUAL REPORT OF PROGRESS,)

CONDUCTED

UNDER THE AUTHORITY OF THE SECRETARY OF THE INTERIOR,

BY

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LETTER TO THE SECRETARY.

WASHINGTON, *January* 1, 1871.

SIR: In accordance with your instructions dated July 15, 1870, I have the honor to present the* second annual report of progress of the United States geological survey of the Territories, conducted under your direction during the present season.

In the field work I have been guided by the following directions, contained in your letter of instructions:

"The area of your exploration must necessarily be discretionary to some extent; but owing to the lateness of the season and the limited time for field-work, it is thought advisable by this Department that the field of your labor be confined principally to Wyoming and such portions of contiguous territories as may be deemed desirable. You will be required to secure as full material as possible for the illustration of your final report, such as sketches, photographs, &c. It is desirable that your collections in all departments should be as complete as possible, and you will forward them to the Smithsonian Institution, to be classified and arranged according to law. You will be expected to prepare a preliminary report of your labors, which will be ready for publication by January 1, 1871. You are referred to your instructions of last season for the details of your duties in the field."

The bill making the appropriation for the survey was not signed by the President until the 15th of July, and immediately thereafter I proceeded to Cheyenne, Wyoming Territory, in accordance with the above instructions.

My party was organized as follows:

James Stevenson, managing director; Henry W. Elliott, artist; Prof. Cyrus Thomas, agriculturist; Wm. H. Jackson, photographer; John H. Beaman, meteorologist; Charles S. Turnbull, secretary; Arthur L. Ford, mineralogist; C. P. Carrington, zoölogist; Henry D. Schmidt, naturalist; L. A. Bartlett, general assistant. Mr. S. R. Gifford, landscape artist, of New York City, accompanied the party as guest from Cheyenne to Fort Bridger. My employés were, one wagon-master, four teamsters, and three cooks and laborers. At Fort Fetterman I employed an old mountaineer as guide and interpreter, through that portion of the country supposed to be infested with hostile Indians.

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* This is really a fourth annual report of progress of the United States geological survey of the Territories. The first and second annual reports will be found incorporated in the reports of the Commissioner of the General Land Office for the years 1867 and 1868. The third is the report of the survey of Colorado and New Mexico, published last winter.

The greater part of our outfit was obtained at Cheyenne. Through the generous kindness of the depot quartermaster at Fort Russell, Colonel C. A. Reynolds, we were enabled to start on our journey, fully equipped, August 6th. The previous year our course had been southward from this point, along the eastern base of the mountains to Santa Fé, in order to study the fine exposures of the rocks of different ages, as they were lifted up by the elevation of the mountain chains. In order that the labors of the two seasons might be connected together, it seemed best to proceed northward along the eastern base of the Laramie range, by way of Chugwater Creek, Laramie Peak, North Platte, Sweetwater, and South Pass. The country along the immediate line of our route was examined with as much care as possible, and frequent excursions were made up the valleys of the little streams to their sources in the mountains, thus obtaining cross-sections from the central nucleus of the mountain ranges extending into the plains. In this way we explored the North Platte and its numerous branches to the Red Buttes; thence we struck across the divide to the valley of the Sweetwater; thence up that stream to its source in the Wind River Mountains. The geological structure of the Sweetwater Valley, although simple, was very interesting, and afforded ample scope for the imagination in reconstructing the numerous phases which it has assumed in past ages. We gave a hasty glance at the Sweetwater mines and the southern portion of the Wind River Mountains, and passed down the Big and Little Sandy Creeks to Green River, and thence by way of Church Buttes to Fort Bridger. Here we established a permanent camp for about twenty days, made numerous side excursions up the Bear River, Muddy Creek, Black's Fork, and Smith's Fork, thus exploring, with considerable care, the northern slope of the Uinta Mountains. This range is one of wonderful beauty, a unique creation, without a parallel in the West, so far as I have yet seen. From Fort Bridger we proceeded southward to Henry's Fork, explored that stream to its source in the axis of the Uintas, then descended its valley to Green River, explored the latter stream to Brown's Hole, and then returned up the river to the Union Pacific Railroad. The scenery and geology of this region are grand and instructive in the highest degree. From Green River Station we followed the old stage road up Bitter Creek, via Bridger's Pass, Medicine Bow Mountains, across the Laramie Plains, through the Laramie range, by way of Cheyenne Pass, to our point of departure, where we arrived about the 1st of November. Here the party was broken up, most of its members returning to their homes. A portion of the month of November was occupied in studying the more interesting geological features along the line of the Union Pacific Railroad from Cheyenne to Salt Lake Valley. Mr. Elliott constructed an excellent pictorial section of the entire road, bringing out all the surface features with remarkable clearness and beauty. In addition to hundreds of local sketches and sections, Mr. Elliott has delineated three continuous pictorial sections across the territory of Wyoming which, if properly engraved, will form a new era in the exhibition of structural geology. The collections in geology and natural history were very large, and many new forms, recent as well as fossil, were added to science. Some idea of the extent of the collections may be obtained from the catalogues which are appended to this report. I take pleasure in acknowledging the great fidelity of all my assistants to the interests of the survey, and their efficient aid throughout the entire trip. My principal assistant, and associate for many years on the plains, Mr. James Stevenson, rendered me the same faithful and indispensable services that have characterized his labors in previous expeditions. Mr. Elliott, the artist, worked with untiring zeal, and his sketches and sections have never been surpassed for beauty or clearness in any country.

The valuable report of Prof. Thomas will furnish ample proof of his constant fidelity to his duties. I regard his report as of great practical interest to the country.

Mr. William H. Jackson performed his duties throughout the entire trip with a true enthusiasm for his art, and the result is about 400 negatives that have hardly been surpassed for beauty or perfection. These pictures throw great light on the singular geographical and geological features of the West, and are, in my opinion, a real contribution to science as well as to landscape photography.

Mr. Gifford, although accompanying the party by invitation for the purpose of studying the grand scenery of the Rocky Mountains in an artistic sense, rendered us most efficient aid, and by his genial nature endeared himself to all.

To Mr. Beaman was assigned the duty of meteorologist, and his report on the subject, herewith appended, will show his zeal in the work. The elevations, though only approximately true, must be regarded as of great value, extending as they do over a country in which very few observations had previously been made. For a large part of the season we followed the old routes of Frémont and Stansbury, and in our examinations we found their reports of great service. So far as the general geographical features of the country are concerned, and the leading facts useful to the emigrant, we found them to be remarkably accurate, and I take pleasure in bearing my hearty testimony to the zeal and ability of these eminent explorers. So far, however, as the geological structure of the country is concerned, but little of a definite character can be found in their reports.

In my report of last year I spoke of the great value of the assistance rendered me by the military authorities of the West. I take pleasure in again thanking them for still more valuable kindnesses the present season. Before leaving Washington I called upon the honorable Secretary of War, General Belknap, with a letter from the Secretary of the Interior, requesting such assistance from the military authorities of the West as could be afforded me without detriment to the service. The Secretary of War at once issued orders in accordance with this request, which were distributed to the different military posts of the West. These orders were indorsed by General Meigs and General Eaton at Washington, by General Sheridan at Chicago, and by General George D. Ruggles, in the absence of General Augur, at Omaha.

My outfit was obtained of Colonel C. A. Reynolds, depot quartermaster, stationed at Fort Russell, and most cordially do I thank him for the friendly interest he took in our welfare. The outfit we obtained here could not have been purchased in the country, however large our appropriation; and besides the great saving to the appropriation, the real interest that both he and his subordinates manifested in providing everything for our comfort and success, called forth the gratitude of the whole party. At every military post we visited we were received with great attention, and the numerous favors, so indispensable in the performance of our duties, were granted us everywhere. In this connection, in addition to those already referred to, I may more especially mention Colonel Chambers, in command of Fort Fetterman, and Lieutenant O'Brien, quartermaster, Captain Gordon and Lieutenant Gregg, of Camp Stambaugh, Lieutenant Shepard, of Fort Bridger, Colonel Bradley, of Fort Steele, and Lieutenant Bubb, of Fort Sanders.

Although the appropriation for the exploration of the year 1870 was very liberal compared with those of former years, I did not feel warranted in employing a topographer, and therefore was able to contribute little of importance toward the improvement of our maps. The maps already constructed by the Engineer Bureau of the Army are undoubtedly the best of any published in America, but in attempting to express the geology of the mountain districts of the West upon them, they are found to be quite inadequate. It has already been shown by the ablest geographers in the Old World, that any topographical map that is not constructed in accordance with well-established laws of geological structure, must be of approximate value only. It is proposed to prepare a map of the districts explored, on a scale of two miles to the inch, not only to express the details of the geology with suitable colors, but also to show, for the benefit of our legislators, the amount of land that can be redeemed by irrigation, timber land, bottom land, &c. Such a map would be of great importance in determining the value of land grants to railroads and other corporations, and would save to our Government many times the cost of the entire survey.

My explorations of the country west of the Mississippi began in the spring of 1853, prior to the organization of Kansas and Nebraska as Territories, and I have watched the growth of this portion of the West year by year, from the first rude cabin of the squatter to the beautiful villages and cities which we now see scattered so thickly over that country. We have beheld, within the past fifteen years, a rapidity of growth and development in the Northwest which is without a parallel in the history of the globe. Never has my faith in the grand future that awaits the entire West been so strong as it is at the present time, and it is my earnest desire to devote the remainder of the working days of my life to the development of its scientific and material interests, until I shall see every Territory, which is now organized, a State in the Union. Out of the portions of the continent which lie to the northward and southward of the great central mass, other Territories will, in the mean time, be carved, until we shall embrace within our limits the entire country from the Arctic Circle to the Isthmus of Darien.

It will not be possible for me in this report to give full credit to all for the numerous favors and courtesies which have been extended to my party, not only during the present season, but for the many years of the past that I have been exploring the West. Many of them were indispensable to my success, and a great source of saving in the expenditure of my limited appropriations. I take this occasion to state that every favor extended to myself or my party by the citizens of the country, by the military authorities, or by railroad corporations, has been in the past and will be in the future credited to the cause which I have endeavored to advance. Every dollar that could be saved I have regarded as so much power given me to place before the world in a proper light the magnificent resources, scientific and practical, of our vast domain in the West.

To Hon. Leland Stanford, C. P. Huntington, and Charles Crocker, of the Central Pacific Railroad; to Hon. John D. Perry and General A. Anderson, of the Kansas Pacific Railway; and to General John Pierce and Colonel Fisher, of the Denver Pacific Railroad, I would tender my grateful thanks for the generous manner in which most important favors were extended to me and to my party, thereby saving hundreds of dollars to the Government.

To the officers of the Union Pacific Railroad, in years past, I have been greatly indebted for free transportation and other courtesies. From General G. M. Dodge, of Council Bluffs, to whom the West is indebted for its material advancement as much as to any one living man, I have always received the warmest sympathy and aid. I have also to thank Dr. T. C. Durant and Webster Snyder, former superintendent of the road, for marked courtesies in the line of my scientific investigations. Scientific men who are truly devoted to their calling cannot be speculators or ardently given to pecuniary gains. Citizens of the country and great corporations must ever be largely the recipients of the material benefits of these labors. Generosity on the part of such corporations toward men who are devoted to the advancement of knowledge or the good of the world, may be regarded as the index of their tone and character. I am glad to say that, with comparatively few exceptions, I have received from the railroad men of the West every mark of appreciation I could desire. In former reports I have frequently mentioned the cordial sympathy of the citizens of the Territories in my labors. I am obliged to speak the truth as I read it in the great book of nature, whether it is in accordance with the preconceived notions of the inhabitants of a district or not, and I cannot depart from this inexorable law for fear or favor. It is my earnest wish at all times to report that which will be most pleasing to the people of the West, providing there is any foundation for it in nature. When I cannot do so, I shall wait for time to place me right in their estimation.

To Dr. G. L. Miller, editor of the Omaha Herald, and Captain William Wilcox and William Stephens, of the firm of Stephens & Wilcox, Omaha, Colonel I. W. French, of Cheyenne, and Miers Fisher, of Denver, Colorado, my entire party have been indebted, from time to time, for material favors of great value. My thanks are also due to Hon. S. F. Nuckolls, of Cheyenne, Dr. Hiram Latham, of Laramie City, J. W. Watson, of Georgetown, D. C. Collier, of Central City, and J. M. Marshall, of Black Hawk, Colorado. The gentlemen connected with the press of the whole West, with very few exceptions, have always given me the most hearty sympathy and assistance in all my labors, and to them I extend my cordial thanks.

I have thought it best to make these preliminary reports the vehicle of much detailed matter which I believe to be useful, upon which I shall hereafter base many generalizations, but which cannot be repeated in a more elaborate final report. The object of these reports seems to me to be to bring before the people at as early a date as possible immediate practical results. I have also endeavored to render them as free from technical language as possible consistent with scientific accuracy. By the hundreds of thoughtful minds all over our country the essays of Leidy, Cope, Lesquereux, Hodge, and Newberry will be read with deep interest. If this report is not as complete as could be desired, I would respectfully direct your attention to the fact that the entire exploration has been made and the report submitted to you in a little less than six months from the date of the passage of the bill authorizing it. It is my hope to be able to continue these reports from year to year, and to make them more complete and more useful to science and to the country.

Very respectfully, your obedient servant,

F. V. HAYDEN,
United States Geologist.

Hon. COLUMBUS DELANO,
Secretary of the Interior.

PART I.

REPORT OF F. V. HAYDEN.

GEOLOGICAL SURVEY OF THE TERRITORIES.

CHAPTER I.

FROM CHEYENNE TO FORT FETTERMAN.

During the summer of 1869 my explorations were directed southward from Fort D. A. Russell, near Cheyenne, Wyoming Territory, along the eastern base of the Rocky Mountains, through Colorado into New Mexico, as far as the Placier Mountains. In order that I might trace the different geological formations northward in their geographical extension and connect the results of the two seasons' examinations, I thought it best to commence the labors of the present year at the same point and proceed northward, by way of Laramie Peak and South Pass.

Fort D. A. Russell is located on the north bank of Crow Creek, a small tributary of the South Platte. The rocks which underlie the country in every direction are evidently of modern date, and belong to the upper tertiary. They are cut through by the little streams, and we find exposed a moderately thick deposit of gravel and boulders resting upon an irregular surface of the indurated marls, sands, and clays of the lake sediments. This is the case in the valley of Crow Creek near the fort, where the vertical bluffs are formed of aluminous marl, with a greater or less admixture of sand. There are also layers of fine indurated sandstone, with small cavities filled with clay and irregular seams of whitish silicious material scattered through all the beds. Near the base of the mountains are small fragments of feldspar. Resting upon what appear to be true tertiary strata are beds of greater or less thickness, composed of sand, gravel, and water-worn boulders, passing up into two to four feet of unstratified marl, with a foot or so of soil. Our course from Cheyenne was directly north along the military wagon-road to Fort Laramie, and our first camp was on Lodge Pole Creek. The surface of the country is beautifully undulating, consisting of rounded hills, ridges, and valleys; but not a tree or bush is to be seen. The same formations occur on Lodge Pole Creek that are noted above on Crow Creek. The strata are the same on all the branches from the foot of the mountains to the North Platte. Horse Creek and its branches are nearly destitute of trees of any kind, and the water is so low that it can hardly be called a running stream; still the soil is good, the bottoms quite broad, and grass fine. For pastoral purposes this valley is very desirable. In order that we may study the geological structure of the country with success we must travel along the base of the mountains, where the different strata are exposed by the elevation of the mountain ranges. To explore the more mountainous portions, we must travel on horseback, and make the road in the plains, which our wagons must adhere to, our base of operations. We can thus make side trips with pack animals to any portion of the country, however rugged the surface, if it presents any objects of interest.

August 7.—This morning the train proceeded across the plains northward to the Chugwater, a distance of about thirty-five miles. With Mr. Gifford and four or five assistants I followed the valley of Lodge Pole Creek to the foot of the mountains, about sixteen miles distant. The surface of the country was undulating and covered with a fair growth of grass; here and there in the valley of the creek, or some side ravine, the rocks are exposed, revealing their age to be upper tertiary. Cream-colored marls and sometimes deep, ferruginous sands are seen, but the prevailing color of the rock material is light drab-yellow. The valley of the Lodge Pole Creek will average about six miles in width from bluff to bluff. The surface of the highlands is covered to a greater or less extent with gravel and stray boulders of moderate size, varying from that of a pin's head to a foot in diameter. Masses of carboniferous limestone are very abundant, showing that these beds were very accessible to the waters during the later drift period. Some of these limestone masses are quite full of fossils, as crinoidal stems, *Athyris subtilita*, *Orthis*, and *Chonetes*. A careful examination of the stray boulders scattered upon the plains will enable one to determine with a great degree of certainty what formations are revealed along the flanks of the mountains. I take the position that these superficial deposits are the result of forces acting from the mountains toward the plains, and that in sweeping down from the flanks across the upturned edges of the beds of different geological periods, as there exposed, they carry portions of each formation with them, and strew them over the plains. Wherever a formation is well developed and exposed, there the more fragments of it will predominate. When the red sandstones are largely exposed, then the drift will be filled with fragments of red sandstone, and the same is invariably the case with the carboniferous strata.

The Laramie Mountains, or Black Hills, as they are usually called, form one of the shore lines of a great fresh-water lake, which covered an enormous area on the eastern slope of the Rocky Mountains during the middle and upper tertiary epoch. When the waters were drained away from this lake basin, a vast thickness of clays, marls, sands, and sandstones was left high on the sides of the mountains, sometimes reaching nearly to the crest or divide. In many localities the beds have not been subjected to as much denudation as in others, and in that case they jut up against the mountain sides so as to conceal all the older unchanged strata, and not unfrequently concealing the metamorphic rocks over large areas.

Along the immediate line of the Union Pacific Railroad, the tertiary beds form a sort of bench, which rises gradually from Cheyenne nearly to Granite Station. The tertiary beds are stripped off only to a moderate extent, revealing a bed or two of carboniferous limestone. A vertical section would show the upper tertiary deposits resting directly, though unconformably, on the carboniferous limestones, and the latter lying on the granites. But on either side, north or south, not only the carboniferous rocks are exposed, but the red beds and, perhaps, the triassic or cretaceous. All along the flanks of the mountains, from Granite Cañon Station northward to the northern boundary of this lake basin, we know that formations of the age of carboniferous, triassic, Jurassic, cretaceous, and perhaps lignite tertiary, exist, whether exposed by the denudation of the White River tertiary beds or not. It is proper, therefore, to color all these formations on a geological map by bands or zones along the sides of mountain ranges. Though if a map were constructed on a large scale and the geology colored in detail upon it, these bands would be somewhat interrupted here and there by the concealment of one or more of the formations, by modern tertiary, or drift deposits. The valleys of the little streams, as they extend down into the plains from the mountains, are usually quite rugged at first, but become less so until the sides are rounded and grass-covered. But along the immediate base of the mountains there is often a valley at right angles to the valleys of the streams and parallel with the mountain ranges, and evidently scooped out by forces acting from them. From the head of Crow Creek to the Chugwater, there is a well-marked illustration of this type of valley. It averages from five to ten miles in width, and the surface is gently rolling, and usually covered with grass. The little streams as they pass across it do not cut deep channels. The eastern side is a high, abrupt, irregular wall of White River tertiary beds, oftentimes so eroded as to present in some degree the architectural appearance of the "bad lands." Through this wall the little streams have cut their channels, and flow down through the plains in valleys with more or less bluff like hills on either side, from one hundred and fifty to two hundred feet in height. Where these parallel valleys occur at the foot of the mountains, the changed as well as unchanged rocks have suffered great erosion. Here and there they are omitted for some reason, and again appear in their full proportions. Immediately north of Horse Creek there is a remnant of the main "hog-back," or ridge remaining, composed of the triassic and carboniferous beds, extending for about five miles, which is divided into three parts by the channels of streams flowing through it at right angles from the mountains. Its trend is nearly north and south, and its dip east; and immediately west the granites and gneiss rise gradually toward the crest of the range. This fragment of the main ridge shows that but for erosion it would have been continuous all along the flanks of the mountains.

An interesting question arises as to the manner in which these parallel valleys have been scooped out. That it must have occurred after the deposition of the latest tertiary beds is evident, from the fact that the streams which form the outlets have cut their way through them. As I have before stated, the mountains formed the western shore of the great fresh-water lakes of the middle and upper tertiary periods. As the mountains were slowly elevated, so that the waters receded, there was a depression at the immediate base of the mountains, of greater or less depth, that received the drainage. The water-course would be gradually formed for the principal streams and their branches. The waters in the parallel valleys formed a sort of lake-like expansion of the little streams, and the waters of the lake performed their work of erosion at the same time that the streams wore their channels through the plains. It is probable that since the close of the tertiary period, and the commencement of the present era, the climate of the west has been much colder; that ice and snow accumulated on the mountain ranges in vast quantities; and that the quantity of water to produce the results which we find indicated by erosion and in the drift was far greater than at present. It may be that ice was not the most important agency, and though the evidence is clear that it performed an active part, yet water was the principal agent, and the present existence of an occasional moderate-sized boulder in the plains, too large to be transported by water alone, indicates that an iceberg was now and then drifted out on the waters to the plains. The grooves, scratches, and smooth sides of the mountain valleys in Colorado and other portions of the Rocky Mountains point to the same conclusion.

From Horse Creek we proceeded northward to the Chugwater, nine miles distant. The road is a perfectly smooth one for wagons. On our right are continuous walls of White River tertiary, pierced here and there by some little branch. On the left the granite rocks are seen in long, irregular ranges, rising very gradually nearly to the summit. The unchanged beds seem to have been worn away to the level of the valley and the edges covered with a deposit of drift. Here and there, however, they are exposed from beneath the White River beds and the cretaceous strata, with the usual ferruginous concretionary masses, which have fallen in pieces; and from these latter have fallen out very good specimens of *Baculites ovatus* and *Inoceramus.*

Near the sources of the Chugwater are some very rich iron mines, which may prove of great value to the country in the future. The fact of their existence has been known for some years, but no definite knowledge of them has been given to the world. In Stansbury's Report, page 266, there is the following paragraph: "In the bed of the Chugwater, and on the sides of the adjacent hills, were found immense numbers of rounded black nodules of magnetic iron ore, which seemed of unusual richness." In the winter of 1859–'60, while attached to the exploring expedition of General W. F. Raynolds, I made a trip to the sources of the Chugwater, and found great numbers of these worn masses of iron ore; but not until a comparatively recent period were they traced to their source in the mountains. During the construction of the Union Pacific Railroad some of the engineers visited the mines and spoke of their future value. In the summer of 1868 I had an opportunity of examining this region in company with Dr. Latham and Judge Whitehead, of Wyoming, and found the mines much richer and more extensive than had previously been supposed. We commenced our examinations in the valleys of the smaller branches of the "Chug" as they emerge from the mountains, and found that the stray masses of iron ore were confined to one of them. Following the branch up into the range we soon came to the ore beds themselves, which we found to be interstratified among the red feldspathic granites which compose the nucleus of the range. The ore beds incline in the same direction with the granites, and have the same joints and cleavage, and the examples of slicken-sides are numerous. They are not continuous, and are confined to a restricted area, yet Mr. Whitehead traced one of the beds a distance of over one and a half miles. The ore is located much like that in the Lake Superior region, and is probably of the age of the Laurentian rocks of Canada. The quantity of ore in this locality appears to be unlimited. Thousands of tons have been washed down into the valley of the "Chug" and distributed among the superficial drift. As we leave the ore beds themselves these stray masses are larger and more angular, and as we pass down the "Chug" they dwindle to minute pebbles and disappear. Mr. J. P. Carson, of New York, an assistant in the survey of 1868, made the following analysis of this ore, at the school of mines, Columbia College:

Sesquioxide of iron		45.03
Protoxide		17.96
Silica		0.76
Titanic acid		23.49
Alumina		3.98
Sesquioxide of chromium		2.45
Sesquioxide of manganese		1.53
Lime		1.11
Oxide of zinc		0.47
Magnesia		1.56
Sulphur		1.44
Phosphorus		a trace
Fe	45.49	99.78

It will be seen by this analysis that the ore is very rich in metallic iron, but it is supposed that it will be reduced with some difficulty. Professor Silliman is of the opinion that the brown ore or limonite can be employed with it, as a flux, with favorable results. Should the time ever arrive when this ore is absolutly demanded by the country it will be easily accessible from numerous points.

It is probable, however, that the branch railroad from Cheyenne to Montana will create a demand for these mines, and then the ore can be taken down the valley of the Chugwater with ease. The Chugwater Creek has its origin high up in the crest or divide of the range, and flows for several miles along a rift or valley of upheaval. It then cuts through a high ridge of sandstone of lower cretaceous age, and then wears its channel through horizontal strata of White River tertiary to its junction with the North Platte.

From Cache à la Poudre to the Chugwater, the Laramie Mountains preserve a remarkable degree of regularity. The line of fracture seems to have been pretty nearly north and south. The singular parallel valley, previously described, ends with the "Chug," and on the north side, extending for four or five miles, are lofty ridges of carboniferous and triassic rocks, trending nearly northeast and southwest, and dipping at a high angle to the southward. From the "Chug" nearly to the Laramie River, these ridges are enormously developed, having almost entirely escaped erosion, and the entire series of sedimentary beds to the summit of the cretaceous can be studied with ease. The most conspicuous feature which we notice in descending the valley is the high wall of lower cretaceous sandstone, which stretches away toward the northeast like a huge wall, and the jointage is so regular that it presents the appearance of a massive mason-work gradually falling to decay. These lower cretaceous rocks, or No. 1, are composed of two beds of sandstone, inclosing thin layers of clay and sand, with seams of vegetable matter or impure coal. Just outside of this wall is a remnant of yellow, chalky, calcareous shale, of No. 3 cretaceous, which escaped erosion when the valley between it and the tertiary wall was scooped out. After the Chugwater emerges from this ridge the valley becomes purely one of erosion, passing through walls of whitish sandstone and marly clays, the layers of sandstone projecting from the sides of the bluffs like shelves. From this point to the entrance into the Laramie River, the "Chug" flows through the same tertiary beds, and they vary here and there in their lithological composition. Near the crossing of the "Chug," where troops are stationed, a hill of brown sandstone appears on the summit of the bluffs, which has protected the underlying softer marls and sands. The sides of these sandstone walls are forty to sixty feet perpendicular, sometimes overhanging, and large masses have broken off and fallen to the base. The most striking feature, however, is the tendency to weather into the most picturesque castellated forms. One isolated hill is circular, and the perfectly flat summit suggested for it the name of "The Round Table."

Another isolated portion of yellow marl, still lower down, stands out so conspicuously to the view of the traveler that it has received the name of "The Pulpit." The marly layers indicate rather quiet waters for their deposition, but the sandstones show currents of greater or less velocity; sometimes they are quite fine and easily decomposed, so that the surface of the plains in the vicinity is very sandy; then they are quite coarse, forming a conglomerate, or pudding stone, mostly of small water-worn pebbles, with now and then a mass six inches in diameter. They also lie irregularly on the arenaceous marls below, as if the surface had been much denuded prior to the deposition of the sandstone. I think, however, there has been no want of continuity in the beds, and that the irregularity is caused by the change from quiet to turbulent waters. Sometimes there is a sudden jog, so that the sandstone projects down two to four feet, into the underlying bed of marl, or it will thin out into indurated marl, to a great extent. For about ten miles these rocks are worn by atmospheric influences into the singular formation described, and then the cap of sandstone disappears, and the surface is more rounded and covered with grass. The texture of the rocks determines everywhere the surface outlines of the country. In the walls of sandstone and marl are deep vertical fissures, much like those in the metamorphic rocks. Sometimes they pass up through the sandstone cap, and at others are checked by it. They are often filled with partially crystallized material, or charged with fine arenaceous sediment from above. The direction of these fissures, or shrinkage-cracks, is northwest and southeast. The plains everywhere present the appearance of remarkable table-lands, as if the surface had originally been planed off with great regularity, and the valleys have been gradually worn out by water. The mountains immediately north of the "Chug" present a fine illustration of the style of flexure which is not uncommon throughout the Rocky Mountain district. The ridges of unchanged formations seem to have suffered scarcely any erosion for a distance of ten or fifteen miles north of the "Chug," and die out in the plains, with a trend northeast and southwest. This causes a jog of about ten miles to the eastward. The pivotal point seems to be Laramie Peak. Long lines of ridges may be seen running out from the main axis, nearly to the head of Bitter Cottonwood; and the trend of the axis extends northwest. These flexures in most cases afford the best opportunities for studying the unchanged rocks of different ages, in their order of sequence, from the granites to the most recent tertiary.

In all my examinations, however, I have not detected the lignite tertiary along the base of the mountains north of Cheyenne, until it makes its appearance from beneath the White River beds, about three miles south of Fort Fetterman.

The Chugwater has a valley about one hundred miles long. It has been for many years a favorite locality for wintering stock, not only on account of the excellence of the grass and water, but also from the fact that the climate is mild throughout the winter. Cattle and horses thrive well all winter without hay or shelter.

The high walls or bluffs which inclose the rather broad valley protect it from the strong cold winds. The soil is everywhere fertile, and, where the surface can be irrigated, good crops of all kinds of cereals and hardy vegetables can be raised without difficulty. From the Chugwater we cross the table-like plains for ten miles, and descend to the beautiful valley of the Laramie. From the plains the Laramie range comes out in full view, with the Laramie Peak near the center, towering far above all the other ranges. The main range, with the numerous minor ranges, trend about northwest and southeast. The tertiary rocks on the Laramie, near the crossing, have weathered into quite remarkable architectural forms, much like those on White River. The texture is similar, also, with marls and calcareous concretions passing up into fine sandstones, which decompose so readily, that the valleys and the hills are covered with loose sand. In the harder layers of sandstone are singular whitish, concretion-like sticks and twigs. A few fossil remains were found—as the teeth of *Oreodon culbertsonii* and *Testudo nebrascensis*. Other bones were collected, which have not been determined. There are also masses of sandstone which appear like mud-rock, and layers like impure white limestone, probably composed largely of sulphate of lime and magnesia. From our camp on the Laramie we enjoyed one of the beautiful sunsets which are not uncommon in this western country. But this was a rare occasion, for the sun passed down directly behind the summit of Laramie Peak. The whole range was gilded with a golden light, and the haziness of the atmosphere gave to the whole scene a deeper beauty. Such a scene as this could occur but once in a lifetime. From Laramie River to the Bitter Cottonwood our road extends over broad, grassy plains, entirely underlaid by the recent tertiary beds. Upon our left the mountains are in full view, and the grassy plains seem to extend to the granite foot-hills. As the Bitter Cottonwood Creek seemed to be the nearest point to the Laramie Peak, we camped here two days to make an examination of that region. On the morning of August 12th I started for Laramie Peak with Messrs. Gifford, Jackson, Elliot, Turnbull, and Ford; passed up the valley of the Cottonwood to the foot-hills of the mountains. Mr. Jackson made a large number of excellent photographic views, which will prove of interest not only to science but also to all lovers of "the picturesque in nature." The scenery in this region is very attractive as well as instructive. The valley of the Bitter Cottonwood, as well as the numerous little ravines that flow into it, are inclosed by rather high bluff-like banks, which show no rocks older than the White River tertiary, until we reach the base of the mountains. Still there is a great thickness of what we have called "local drift," which increases to the base of the mountains, and to a great extent conceals all other rocks. This superficial drift becomes coarser and the stray rocks less worn the higher we ascend. The difference in elevation between our camp on the Cottonwood, and the base of Laramie Peak—a distance of twenty-five miles—is about one thousand eight hundred feet. I have previously noticed the enormous development of the sedimentary ridges north of the Chugwater, and the flexure of the mountains around to the north and northwest; also, the dying out of the ridges in the plains one after the other in the usual *en echelon* manner. Between Laramie Cañon and Horseshoe Creek these ridges are not seen at all, rising above the surrounding country, and they are exposed only in one locality, to a limited extent, by one of the branches of the Cottonwood, cutting a deep valley through the superficial drift and tertiary beds, just at the base of the mountains. The red beds and carboniferous limestones only, are seen on each side of the road which leads from Fort Laramie to Laramie Peak. Here are two small rounded hills capped with carboniferous limestones. Still, for the most part, the drift and tertiary beds jut up against the granite foot-hills, and the long, table-like benches extend down for miles with a gradual but rather rapid descent, giving a far-extended but beautiful and picturesque appearance to the scene.

Between the Chugwater and the Laramie River the surface seems to have escaped erosion to a great extent, while between Laramie River and the Bitter Cottonwood Creek the erosion has been tremendous. All the ridges, which must have been from five hundred to one thousand feet in height, have been smoothed down and concealed, and the gneiss and granites which form the foot-hills or lower ranges have been worn away so that they project but little above the surface. We have therefore a belt of country underlaid by metamorphic rocks, five to ten miles in width, covered with most excellent grass, as level as the plains, and very desirable for settlement; which, but for erosion, would have been as rugged as any portion of the mountainous district. As we approach the mountains, we pass over many beds of quartz, black gneiss, seams of feldspar, with now and then a bed of massive feldspathic granite. These rocks are nearly vertical in position, and in most cases project above the superficial drift so as to be barely visible, with a strike nearly north and south. The intercalated beds of massive unstratified feldspathic granites are thin at first, while the gneissic beds are the most prominent; but as we approach the base of the mountains the red feldspathic granites rise in thick picturesque ridges, fifty to one hundred feet high, like ruined walls, lending a peculiar as well as picturesque appearance to the landscape. These granites afford most excellent rock studies of their kind. The tendency to weather into rounded forms by exfoliation and the jointing are shown very finely. The principal lines of fracture are most continuous, and have a strike east and west, and southeast and northwest, while the other set trend nearly north and south, or northeast and southwest. The tendency to exfoliation by the stripping off of thin concentric layers has enlarged the openings sometimes several feet. The granites are thus divided into rather regular rhomboidal masses, many of which have fallen down at the foot of the ridges, and by exfoliation have been so rounded that they appear like immense transported boulders. The texture of the rock is really an aggregate of large crystals of reddish feldspar, with quartz and mica; the feldspar so predominating that it gives the character to the rock. The mica usually occurs in small masses and in limited quantities. The gneissic rocks are divided by the jointing into more regular cuboidal blocks, and have suffered comparatively little from exfoliation. The gneissic strata diminish while the massive granites increase as we approach the main range, which is composed almost entirely of the latter. The examples of anticlinals and synclinals in the metamorphic rocks are nowhere better shown than around Laramie Peak. It would require a detailed geographical as well as geological survey, with maps and sections constructed on a large scale, to show the various axes of upheaval.

The valley of the Cottonwood Creek, which extends along the east base of Laramie Peak and rises about five miles south of it in the main crest, is a beautiful synclinal. A series of short parallel ridges rise to the very summit of Laramie Peak, on the east side, inclining eastward, while on the opposite side is a similar series of ridges, although much lower, dipping to the westward. These anticlinal and synclinal openings give passage to the little streams and ravines or form the open grassy plains which are so pleasant to the Indian. Sometimes these valleys expand out into beautiful oval, park-like areas, which at the present time are the favorite resorts of the wild game, and, if the country were ever settled, would attract a pastoral people. Emigrants from the mountainous districts of the Old World would find here a scenery not unlike that of their own country, with pure air and water and a mild and extremely healthy climate. Cereals and roots of all kinds could be raised sufficient to supply the wants of such people, while the raising of stock would be a source of wealth both to them and to the country. It is somewhat strange that the Laramie range should give origin to no important stream. Both the Platte and the Laramie Rivers flow directly through it. While the springs or little streams are not uncommon, this range cannot be regarded as well watered, and in the autumn the water supply is somewhat limited. This may be accounted for from the fact that the snows of winter are very light and the amount of rain falling during the year quite moderate. Laramie Peak, which is the highest point north of Long's Peak, is not more than ten thousand feet high, and usually retains no snow on its summit after May. One fact is quite clearly shown, along the immediate base of the mountains from the Chugwater to the Bitter Cottonwood, that when a flexure in a mountain range occurs, a portion of the foot-hills and ridges have suffered very little erosion, and can be studied in their full development. For a distance of fifteen miles north of the Chugwater the local erosion from the mountains was very limited, while from Laramie River to the Bitter Cottonwood, about fifteen to twenty miles, the erosion has been tremendous. This difference can be accounted for, perhaps, from the fact that the passage of the waters from the mountains was through the anticlinal and synclinal valleys which extend nearly north, and swept over the plains between the Cottonwood and the Laramie Rivers. Long parallel benches, with remarkably regular, table-like surfaces, extend down from the base of the mountains between the valleys of the streams. Their uniformity over such large areas is a striking feature in the landscape. North of the Cottonwood these long benches have a singularly regular series of side furrows, which extend for miles, and give to the surface the appearance of the sea swept by a gentle breeze. We have not before observed this feature, so well marked, although the parallel benches are not uncommon.

On the morning of the 14th we left Cottonwood Creek for the La Bonté. The wagon road, although several miles from the Platte River, is still ten to fifteen miles distant from the foot of the mountains. The White River tertiary beds prevail, for the most part, and here and there are high hills, or "buttes," of marls and sandstones, weathering into the castellated forms, before described, but to a limited extent. Still, these beds continue to possess a thickness sufficient to conceal the underlying older formations. Between the Cottonwood and Horseshoe Creeks these deposits are overlaid by a heavy thickness of local drift, and jut up against the granites until we come to the immediate valley of the Horseshoe, where it emerges from the foot-hills. Here is a singular valley of erosion on the south side. A small branch flows into the Horseshoe, uncovering the ridges of carboniferous limestones and red beds, over an area of about a mile in length and half a mile in width; still, on the opposite or north side of the Horseshoe, the drift juts full against the granite sides. This example shows clearly, that even where they cannot be seen at the present time these sedimentary ridges exist in greater or less force all along the mountain flanks. There is no water in this little branch for a great portion of the year, yet all the superficial drift or White River sediments have been washed out, leaving the skeleton-like ridges of the older rocks. In one place the limestones rest directly on the granites. The dip of the ridges is about 60°, and they are two hundred to two hundred and fifty feet in height above the bed of Horseshoe Creek. That the Jurassic and cretaceous beds exist all along here we cannot doubt, but they are entirely concealed. The valley of the Horseshoe is about three miles wide from bluff to bluff. The cream-colored marls lie close up to the granite rocks. We have usually observed that the sediments of the later tertiary strata were coarser the nearer we approach the base of the mountains; but this does not seem to be the rule. In some localities the finest marls and sands rest directly upon the metamorphic rocks or fill up the inequalities in the surface far up among the foot-hills nearly to the crest. This range of mountains, however, seems to have formed a well-defined shore line for the lake, for we can find no evidence that the waters passed the divide in the Laramie Plains, although they washed the flanks far up toward the summit.

From the north side of the Horseshoe Creek we have the most imposing view of Laramie Peak, with the intervening mountain ridges. They show a trend about southeast and northwest. Between Horseshoe and La Bonté the black gneiss beds must be two thousand to three thousand feet in thickness, extending in long lines across the country nearly north and south, just projecting above the surface, nearly vertical. For ten miles or more the White River tertiary beds conceal the mountain flanks; but from five to fifteen miles northeast of the range, toward the Platte River, the older beds are uncovered over very restricted areas. At the head of a little branch of La Bonté two ridges of reddish sandstone and limestone rise up from beneath the tertiary beds, inclining 10° to 15° east of north. The little dry branch has cut through the rift between the ridges caused by the uplift, showing one of them to be composed mostly of bright brick-red sandstone, with a layer of light gray sandstone tinged with red, (triassic;) while the other ridge is made up of carboniferous limestones and sandstones. In the limestones are seams of chalcedony, from which most of the varieties of flint scattered through the drift are doubtless derived. Sometimes these isolated hills are elevated in such a way that the two sides incline in opposite directions, forming a fissure at the summit, through which the waters find their way, thus wearing out a gorge or cañon. In the interval between Horseshoe and La Bonté Creeks, and west of the Platte River, the older sedimentary rocks, as carboniferous, triassic, Jurassic, and cretaceous, are uncovered in spots by denudation, always inclining from the mountains at a high angle. The pine forests in the mountains at the sources of the Horseshoe and the La Bonté are more dense, and the timber larger, than in any other portion of the range that we have seen. Great abundance of ties for railroad purposes could be procured. Our camp in the valley of the La Bonté was a pleasant one; a fine, luxuriant growth of grass covered the immediate bottoms of the creek, and our animals found excellent grazing on the uplands also. The creek is bordered with bitter and sweet cottonwood, box elder, and large tree willows to a considerable extent. The soil is certainly fertile enough, and where it can be irrigated, will produce fine crops of all kinds. This will prove one of the best valleys along the North Platte, both for agricultural and pastoral purposes.

On the morning of the 16th we left La Bonté Creek for Fort Fetterman, which is located near the junction of La Prele with the North Platte. The atmosphere was very smoky, limiting our range of vision considerably, so that we could not see the mountains distinctly. Just north of the La Bonté are a series of anticlinals and synclinals, which are somewhat different from any before observed. The road passes along a synclinal valley, with the red sandstones (triassic) inclining southwest on our left, and the Jurassic, with an outcropping of the red beds at the base, about a mile distant, on our right, dipping northeast. The beds on our left dip about 30°, while those on the right not more than 10° or 15°.

The end of one ridge inclining southwest apparently juts up against another inclining northeast. These irregularities are local, and are due, perhaps, to the variableness of the internal forces that produced the elevations and the different degrees of strength of the earth's crust.

There is an immense ridge, or "hog-back," extending from the La Bonté to the Red Buttes, which forms an illustration of these apparent irregularities in the exhibition of the interior forces, on a large scale. We can express them no better than to call them "puffs," or local risings of the earth's surface, which cause a fracture along the central axis in rather regular lines, and this fracture gives access to atmospheric influences which gradually wear out an anticlinal valley. These anticlinals vary from a few hundred yards to many miles in length, involving a few beds or all of them down to the granite. We regard each great range of mountains, as the Laramie range, Black Hills, Wind River range, Big Horn range, &c., anticlinals on a grand scale; all the ridges, whether composed of changed or unchanged rocks, inclining, step-like, from one central axis.

In the distance, near the North Platte, a bluff-like wall can be seen, composed of the White River tertiary beds, nearly horizontal or inclining at a very small angle. This abrupt wall is more or less continuous all along the shore of this ancient fresh-water lake, and marks steps in the progress after erosion. It shows that the sediments once extended up to the flanks of the mountains, with a thickness of several hundred feet more than at present. Between this wall and the sides of the mountains, which vary in distance from two to twenty miles, there are always remnants more or less continuous, with greater or less thickness. It is from underneath these beds that the older rocks appear, here and there, over an area sometimes of only a few hundred feet, or extending several miles. About five miles north of La Bonté, close by the traveled road, there is a somewhat remarkable conical butte, composed of fine gray sandstones, portions of it approaching a quartzite. The butte is about fifty feet high, with a dip 35° to the northeast, and looks like a mass of rocks that had been transported from some other locality and lodged there, for there are no others of the kind for a considerable distance on either side. The explanation appears to be, that this is an isolated portion left after the erosion or denudation of this valley. About half a mile to our left there is a long parallel ridge inclining northeast toward the Platte, with the basset edges of the rocky layers on the southwest side towards the road. At the base a small portion of the red beds is visible; above them the Jurassic series. Over the red beds, and forming a sort of transition or bed of passage between them and the Jurassic series above, is a layer of this same sandstone, thirty to fifty feet in thickness. This anticlinal valley is about five miles in length and a mile in width, and is now occupied almost entirely by the red beds, while the gray sandstones, and doubtless the more recent formations, Jurassic and cretaceous, extend over the whole area; and this butte, with a few masses of sandstone on some low elevations close by it, is all that is left at the present time. I call them remnants, monuments, or landmarks, left after erosion to assist us in reconstructing the ancient form of the earth's surface. We cannot say that, because a formation or series of formations do not exist over certain areas at the present time, they did not once exist there, and that too in their full development. How these isolated portions escaped the general erosion it is somewhat difficult to determine. The currents of water, which seem to have come from the direction of the mountain range, were perhaps turned aside by some obstruction thus passing around them; no debris of any kind has lodged on the sides of the butte. The entire plain country of the West affords examples of these buttes, and I have often alluded to them in former reports. Bijoux Hills, on the Missouri River, Turtle Hill, Deers Ears, Thunder Butte, Church Buttes, Pulpit Rock, and many others which have been regarded as worthy of a place on our best geographical maps, are examples of this kind.

A glance at the map will show that the Laramie Mountains have bent around westward so as to cause the upheaved ridges to incline about northeast, and as the range continues to curve the ridges to incline north and even to the northwest, following the bend of the axis of elevation. In the red beds, between the La Bonté and La Prele, are some layers of fine white amorphous gypsum. About ten miles from La Bonté we cross Spring Creek, a small stream without wood, where travelers sometimes halt for lunch or rest. The most conspicuous feature here is the bluff wall of tertiary, which extends up westward so as to form the high hills on the north side of the valley. The waters have worn deep into the cream-colored marls, so that we have over a restricted area miniature "bad lands." The dome-like hills and the numberless furrows down the sides, the harder layers projecting out like verandahs, are well shown. Three miles before reaching Fort Fetterman, the lignite beds make their appearance from beneath the more modern deposits, exhibiting their peculiar lithological characters in a marked degree. The strata dip 20° northeast, and where seen in apposition, the White River tertiaries do not conform. Seams of lignite and great quantities of brown iron ore occur here. Some of the iron ore is quite rich, but most of it is very lean. The prevailing constituent in all the rocks, sands, sandstones, clays, &c., is iron, presenting every shade of color that can be derived from that mineral, the yellow iron-rust color predominating. There are, however, some layers of quartzite or coarse sandstone, which is very compact and nearly black, and some of it contains a fair percentage of iron. As soon as we come to these beds, the entire surface of the country presents a somber hue, more rugged and less fertile; due probably to the greatly diminished amount of calcareous matter. Much of the country has a burnt appearance, due, probably, to the oxidation of the iron. Fort Fetterman is pleasantly located on a bench-like point between the La Prele and the North Platte, near their junction. It commands a fine view of the country in every direction, but more especially up the Platte Valley, which can be seen for ten miles or more, with its sinuosities and its pretty fringe of fresh green foliage. All the underlying rocks on both sides of the Platte, as well as the La Prele, for several miles around, belong to the eocene or lignite tertiary period. The soil everywhere seems to be productive. Several of the officers at Fort Fetterman have made experiments in raising vegetables in a small way with success. It is the opinion of Colonel Chambers, the commander of the post, that with suitable irrigation, all the more important crops can be raised with ease.

On the morning of the 17th we made a short side trip from the fort up the valley, to the cañon of the La Prele. Lieutenant O'Brien and Captain Wells accompanied us to point out the location of a remarkable natural bridge, which was said to rival the famous one in Virginia, with which every school-boy is familiar. We found it even more wonderful than we had anticipated, and it is a matter of surprise that so great a natural curiosity should have failed to attract the attention it deserves. The cañon is about ten miles from the fort, and is formed by the passage of La Prele Creek through a long ridge that extends from the La Bonté to Red Buttes. The cañon is one of upheaval and erosion. The ridge is a long, local anticlinal or "puff," and the strata incline from each side of the summit. The gorge is very irregular and tortuous, filled with huge masses of rock that have fallen down, obstructing the passage. Where the stream has cut through the rocks direct we have vertical walls on each side and a narrow gorge; but where the channel passes along a rift the valley expands out several hundred feet. Where the La Prele emerges from the cañon it cuts through the limestones and red-beds at right angles, forming a regular gorge, with walls fifty to one hundred and fifty feet high. At the head of this gorge the stream has at some time changed its bed, passing directly through a point of rocks that extends across the channel. The old bed is now overgrown with trees and bushes, but is fifty feet higher than the present one. The little creek must have changed its course slightly, for some reason not apparent now, so that its waters were brought against this point or wall of rock, and finding a fissure or opening through, it gradually wore its present channel. It is certainly as perfect a natural bridge as could be desired. The opening under the bridge is about one hundred and fifty feet wide and fifty feet high. The old bed is about three hundred feet to the northwest. It is also plain that the water at one time flowed over the top of the bridge, which is fifty to one hundred feet lower than the top of the gorge, so that we have here some of the intermediate steps which a stream takes in the process of wearing out a gorge or channel. The rocks are mostly limestone, quite pure, arenaceous limestone, and at the base very cherty limestone. I found a few fossils in the cañon in a blue limestone, as *Hemipronites crassus*, *Productus nodosus Myalina perattenuata*, &c. I think all the rocks are of carboniferous age, although some of them may be Silurian. Whatever the age of the rocks may be, there seems to be a great thickening of them as we go westward. This ridge, which is twelve hundred feet above the base, is composed entirely of what I have usually classified as carboniferous rocks, and nowhere in the cañon, which is at least half a mile in length in a straight line, have the waters worn through to the granites. On the west side of this ridge the beds incline west, northwest, and southwest, and between it and the main mountain range there is an interval of ten to fifteen miles in width, with one or two ridges of limestone and sandstone dipping from the mountains. This broad interval forms a beautiful, grassy valley, which is a great resort for game, and will some time afford fine pasturage for stock. The metamorphic rocks soon make their appearance. On the northeast side of the ridges the White River beds lap on the flanks in many places, but here and there they are stripped off so as to reveal the red-beds, Jurassic marls, and the cretaceous. Six miles of the valley between the cañon is covered with the modern deposits, and the remainder of the way to the fort, with the lignite beds, which are shown in high, cut bluffs of ferruginous sands and sandstones. We were indebted to the hospitable officers of Fort Fetterman for a very pleasant and instructive day.

We will now notice briefly the geological character of some of the well-known localities contiguous to but not immediately on the route. The White River group, which we have had occasion to mention so often, extends from La Prele Creek eastward nearly to the Missouri River. It is therefore the prevailing formation in this region. Scott's Bluffs, Chimney Rock, and Court-house Rocks are well-known landmarks on the North Platte, belonging to the White River group. A few miles north, or northwest, of Fort Laramie is a group of high hills rising above the tertiary beds, exposing a considerable thickness of carboniferous rocks, with an extensive series of gneissic strata; and here and there a nucleus of feldspathic granites. Raw Hide Butte, which gives origin to several streams, as Raw Hide Creek and a branch of the Nio brara River, rises above the surrounding country six hundred to eight hundred feet, and exposes a nucleus of reddish feldspathic granite, with gneissic strata inclining from its sides, with carboniferous limestones reposing unconformably upon the upturned edges. In some cases the limestones are elevated to the summits of the hills in a nearly horizontal position. All these isolated mountains seem to have been islands in this great tertiary lake. There is no doubt that all the formations that succeed the carboniferous period, as triassic, Jurassic, cretaceous and lower tertiary, once covered them in their full thickness, but they have all been swept away. Now the more modern tertiary beds jut up against their sides or are deposited high up in the ravines, indicating by their position that this lake existed here after the mountains had attained nearly their present elevation. There is also an anticlinal valley more or less distinct, extending across the intervening country, connecting those elevations with the Black Hills and the Laramie Range. The fact that nearly all of the ranges, however small they may be or distinct from each other, are connected together by some link however obscure, illustrates the unity and simplicity of the Rocky Mountain system.

CHAPTER II.

FROM FORT FETTERMAN TO SOUTH PASS.

On the morning of the 20th we left Fort Fetterman for the South Pass by way of the Sweetwater. Our first camp was on Box Elder Creek, twelve and one-third miles up the valley of the North Platte. The lignite tertiary beds are the only rocks exposed, and they incline north and northwest 5° to 15°. They are composed of rusty sands and sandstones, arenaceous clays, with some seams of impure lignite. Some of the sandstones are largely concretionary, and break in pieces readily on exposure. The high ridge to the west of us trends about northeast and southwest. Along the base of the ridge are some terrace-like benches, perhaps broken fragments of higher levels not swept away. They extend at intervals as far as Fort Casper. In some instances they jut up closely and even lap on to the flanks of the ridge They are remnants of the White River group, which once extended uninterruptedly over the whole valley close up to the ridge, but which has been washed away, except these fragments. They now seem to give that beautiful bench-like aspect to the surface, which, contrasting with the rugged features of the ridge, adds interest to the scenery. They nowhere incline more than 5°, and in most instances are horizontal, never conforming with the older formations. It is most interesting, by means of these remnants, to trace the old shore-line of the lake, which can be done as perfectly and as clearly as that of any of the northern lakes of the present time. This hog-back or ridge seems to have formed an effectual barrier to these waters on the north side of the Laramie Mountains.

The Box Elder Cañon affords a good section through the ridge. It is a much more regular gorge than the cañon of the La Prele, and is purely one of erosion, and is six hundred to eight hundred feet in depth. It is so narrow that it is difficult to pass through it on foot, and the sides are perpendicular, and sometimes overhanging. The predominating rocks are sandstones, or calcareous sandstones, with some layers of quite fine limestones, but there is a great variety of texture. Some of the layers indicate very quiet deposition for forty or fifty feet, but the greater portion of the sandstones is full of irregular layers, showing clearly the nature of the waters at the time. The prevailing color is light yellow, varying to a deep rusty hue, but there is often a tinge of brick red which is marked at some localities. The sandstones are full of beautiful siliceous geodes. The crystals of quartz are mostly small, but very clear, and are set in a layer of amorphous silica or chalcedony as a paste. In the cherty limestones are very distinct fossils, as *Athyris*, *Orthoceras*, and others. Near the summit of the ridges the gorge becomes very deep and narrow, and the granite rocks are well exposed, with the unchanged beds directly in contact. In the valley of a small stream about four miles above, the unchanged beds extend only up to the foot-hills, while their relation to the metamorphic rocks is perfectly clear. Resting directly upon the granite rocks is a bed of reddish sandstone and quartzite, sometimes so coarse as to be called a pudding-stone, which I have no doubt is Lower Silurian, (Potsdam.) No fossils could be found, but the character and position of the rock render it most probable that it is of that age. Above it, without any apparent unconformability, are beds of limestone and sandstone, which I have regarded as carboniferous, though a portion may be of older date. Receding from the foot-hills is a series of low ridges, of Jurassic, cretaceous, and lignite strata, as far as the eye can reach—far across the Platte. The red beds are not clearly shown, but there are remnants of them on the flanks to show they once existed here. The White River beds which jut up against the sides of the ridge are largely made up of reddish, indurated sand, no doubt derived from the ground-up materials of the red beds. Among the carboniferous rocks of this region are beds that could be made useful for economical purposes. The yellow, rather chalky limestone near the summit of the ridge is rather magnesian, and could easily be wrought into fine building materials. It somewhat resembles the magnesian limestone so much in use near Junction City, Kansas, but it is more chalky. It contains a few small cavities filled with quartz crystals, but not to such an extent as to prove an injury. The surface exposed to the atmosphere is covered with beautiful, basin-like depressions, in which the rain-water accumulates, showing that it is acted upon readily by the atmosphere. The mountain ridge which we have been examining runs out in the valley of Deer Creek, about fifteen miles above the Box Elder, producing a jog. A second ridge comes in about five miles back of this, which fronts the Platte for ten miles, where the Casper Ridge juts in abruptly and ends with the Red Buttes. This jog occupies an area about five miles wide and ten miles long, and has been so smoothed by denudation that it is very beautiful to the eye, and always has been an attractive place for herdsmen.

Eleven years ago I passed a portion of the winter in this valley, connected as an assistant with an exploring party under the command of Captain W. F. Raynolds, United States Engineers. Our stock, which amounted to nearly two hundred mules and horses, was wintered very nicely in the valley of Deer Creek near this jog, without a particle of hay or grain, with only the grass which they gathered from day to day. The climate was mild and the snow never deep, so that the ground was always exposed to some extent. The present season the hay for winter use at Fort Fetterman is obtained from this valley. The geology of the valley of Deer Creek is very interesting in its details, and I regretted that I could not spend more time at this point. From its junction with the North Platte for five miles of the valley the lignite beds are well developed, revealing the usual sandstones, indurated clays, &c. Near the mouth of Deer Creek a coal-bed was on fire in the winter of 1859–'60, and I was informed that it is still burning. The surface is heated and much of the earth baked a brick-red color for a considerable space. Five miles up the valley the black clays of No. 4, capped with a thin bed of ferruginous arenaceous clays, No. 5, is exposed in the bluffs by the creek. Underlying a long bench which extends down from the foot of the upheaved ridges are two quite striking beds of sandstone. The lower one is concretionary entirely; that is, it is filled with spherical masses of sandstone of all sizes from a few inches in diameter to several feet, which split horizontally into thin laminæ. The indurated sandy clay in which these concretions are inclosed exhibits the same concretionary, character so that the rocks weather into curiously fantastic forms. This bed is undoubtedly cretaceous, and is probably a bed of passage to the lignite tertiary. A few fossils are found in the harder masses, as *Inoceramus*, *Baculites*, &c. Above this bed is a thick group of grayish-brown sandstones, with rusty brown concretions, which also weather into curious architectural forms. These benches extend nearly to the foot of the upheaved ridge, with only a slight inclination, perhaps 5°. The older beds are exposed forming a very narrow belt.

Our camp on the night of August 21 was near the mouth of Muddy Creek, on the North Platte, thirty-four and one-fourth miles northeast of Fort Fetterman. Muddy Creek rises in the Laramie range, cutting a remarkable cañon through the eastern end of Casper Mountain, one of upheaval and erosion combined. The eastern end of this singular ridge is about fifteen miles southwest of the mouth of Muddy Creek, and continues nearly parallel with the Platte for twenty miles or more until it ceases at the Red Buttes. About noon of the 22d we left the Platte near the mouth of the Muddy and struck across the intervening country in a southeast direction, to make an examination of this interesting ridge. The scenery at the head of the Muddy is very remarkable, and, so far as dynamical geology is concerned, would well repay a week or two of diligent study. Casper Ridge seems to trend nearly northeast and southwest, and the rocks which cap the ridge dip slightly southeast. The ridge is capped with carboniferous limestones and Potsdam sandstones, and these form a high wall abutting northwest toward the Platte, as if the whole mass had been lifted up eight hundred to one thousand feet above the plains below, in a nearly horizontal position, and the edges had been broken off all round, and the fragments are now found lying against the sides in a highly inclined position, or have been washed away. The eastern end has escaped erosion, for the ridges are here quite large. The Muddy flows through a narrow valley, for a mile or two over a portion of the red beds—a high ridge on the left, composed of heavy beds of bluish limestone, red argillaceous sands and sandstones; immense beds, capped with a massive bed of fine pudding stone, which I have usually regarded as the bed of passage between the Jurassic and cretaceous. This is the first time I have noticed these pudding-stone beds north of Cache à la Poudre. They are well developed and persistent through Colorado and New Mexico, but apparently disappear, in part or entirely north of the Union Pacific Railroad. But here we find them appearing quite suddenly in full development. Immense cubical masses have fallen from the ridge, twenty feet thick. This pudding-stone is composed of smoothly worn pebbles cemented in a paste of sand, and disintegrates slowly, and is so hard that a fracture passes through the pebbles. It would polish well, and make an excellent building rock. These tilted ridges seem to bend around toward the south side of the Casper Ridge, and I have no doubt it may be regarded as an oblong quaquaversal. The edges which have broken off, or bent down, incline from all sides of the central portion.

The Muddy Creek issues from Casper Ridge in two branches, cutting deep and most picturesque gorges through the yellow and reddish carboniferous rocks. The walls of the cañons show on the outside the beds inclining 40° to 60°, but in the ridge the beds are nearly horizontal from base to summit, five hundred to six hundred feet. These gorges show quite clearly the anatomy of the ridges. Passing from the east end of the ridge westward, we find that for about a mile the broken portions lap on to the sides of the ridge in regular order, then for about five miles they have been entirely swept away, revealing the metamorphic rocks in places and the contact of the unchanged beds with them. An immense deposit of debris covers the lower ridges at the base and juts up against the sides of the ridge; the nearly vertical edges of the fragmentary ridges project above the debris, as remnants left after erosion. The debris or superficial drift is so great that it juts up against the side of the ridge at least six hundred feet above the bed of the Platte, concealing, to a great extent, the underlying formations. Still portions crop out occasionally, showing that they exist. The ridges of cretaceous and lignite tertiary are very distinct in the plains, inclining from the mountain at a small angle. Near the Platte, about ten miles above the Muddy Creek, there is a considerable area covered with light-gray sandstones, which have weathered into most unique forms. They resemble the ruins of some old village, portions of the stone walls with the chimneys remaining. One mass of rock we called the "Blacksmith's Forge." The material is a fine gray sandstone, with very irregular layers of deposition. No single lamina can be traced continuously more than a few feet. The rock is also full of rusty, ferruginous, hollow nodules. It has been weathered full of holes and caves, which give it a picturesque appearance. These afford fine places of retreat for wild animals. The sandstone is so soft they have been enabled to extend the natural cavities at pleasure. When examined with a glass the sandstone shows small particles of quartz, with a few grains of feldspar and mica, loosely held together. The dip of all the tertiary beds is northeast 5° to 20°. A bed of lignite crops out in many places. Near old Fort Casper the long benches that extend down from the base of the ridge toward the Platte form a marked feature in the surface. They are composed of tertiary and cretaceous beds, and the latter formation is better shown here than at any other point north of the Chugwater. These benches are really table-lands, their surface appearing even and smooth to the eye. Just above the bridge are some high bluffs on the left bank of the Platte, composed of lower cretaceous clays, No. 2. On the summit of the hills, about four miles east of the Red Buttes, are some quite prominent ledges of yellow ferruginous sandstone with *Inoceramus* and huge rusty concretions; underneath them are the black shaly clays of No. 2, with all the evidence of barrenness which they carry with them. There seems to be an unusual exposure of the cretaceous beds for about fifteen miles, and they jut up close to the base of Casper Ridge. The beds incline from the ridge in regular order, and follow its flexures.

Our camp near the Red Buttes was an interesting and instructive one. We were located on a broad, grassy bottom of the Platte, in a sort of amphitheater, with the rocky beds rising to a great elevation all around us. The Red Buttes are so called from the high ridges or groups of ridges which are separated by the channel of the Platte. The basset edges of the beds bear eastward toward our camp, and a layer of the brick-red argillaceous shales is exposed. As we approached them from the east in the afternoon, the rays of the setting sun greatly heightened their color and brought them out in relief, so that we could readily see why they have been such prominent landmarks and have so long attracted the attention of the traveler. These buttes, taken together, may be regarded as an irregular anticlinal, with one side formed of quite lofty ridges, and the opposite side fragments of low ridges, which look as though they had broken off of the edges of the opposite portion during the upheaval. The red beds are well exposed, with a thickness of four hundred feet, and above them are the Jurassic beds, with *Pecten*, *Belemnites densus*, and a small species of *Ostrea* in great numbers. The summit is capped with the thick layer of pudding-stone described as occurring near the source of the Muddy, huge masses of which have fallen on the side and at the base of the ridge, looking like gigantic boulders. One of these masses is twenty-eight feet in all its dimensions, and is composed of water-worn pebbles, varying in size from a grain of quartz to an inch in diameter, set in a cement of sand. The large, amphitheater-like area inclosed by the Red Buttes and vicinity might be called an imperfect quaquaversal, composed of a number of anticlinals and partial quaquaversals. On the north side of the Platte an anticlinal extends off toward the northwest, showing in a small area the upper portion of the Jurassic with a full development of the cretaceous. The two sides come together in a distance of five or six miles and finally die out in the plains. The Platte passes through this anticlinal. On the south side of the river the two sides of the anticlinal are well shown, but only the cretaceous and Jurassic beds are exposed. In the former are four or five layers of sandstone with interpolated beds of indurated sandy clay, and separating the two formations is a massive bed of quartzite or sandstone, of variable thickness as well as texture, ten to thirty feet. On the east side of the Platte is quite a remarable gorge or cañon, which was first observed by the zealous photographer of the expedition, Mr. Jackson of Omaha, and in whose honor we called it Jackson's Cañon. The waters of a former period (for the gorge is a dry one at the present time) have cut directly down through the limestone, much as they have at Box Elder and at the head of the Muddy. The gorge is two hundred feet wide at the top, and sixty to seventy feet at the bottom, and three hundred and fifty feet to four hundred feet deep. From the cañon the red beds incline in a series of ridges which form one-half a circle. These red beds contain irregular seams of gypsum. Far to the northwest the Big Horn Mountains can be dimly seen, and the intermediate space between them and the Platte is slightly disturbed by lines extending across the plain toward the range. These lines of disturbance, or anticlinals, seldom bring to the surface rocks older than cretaceous. At Piney Butte the Jurassic beds are exposed over a very small area. It appears that at this point the Laramie range breaks up into several lines of disturbance, extending far across the plain toward the Big Horn range. So far as I can ascertain, the ranges are there more intimately connected than with any others to the westward. They both form the outer or eastern border ranges.

On the morning of the 26th we left our pleasant camp near the Red Buttes, and passed over the high ground to the westward, with the Buttes on our left, and the ranges of the Big Horn dimly visible on our right. In looking back from the west, eastward, on the ridge of which the Red Buttes form a part, we can see that the general dip is about southeast or south, inclining gently down to the plain. About four miles west of the Red Buttes, on the north side of the road, are the most remarkable semi-quaquaversals, one of which looks much like a crater. The northwest side forms a perfect rim, while the southeast is open, with a dry valley alongside, into which the materials within the rim have been washed, so that it forms half an amphitheater, with the inclosed space smoothed off and grassed over. The southeast end of Piney Butte Ridge is separated by a synclinal, not more than one hundred yards wide. The ridges form a complete half circle, and they extend across the country far to the northwest. Between the Red Buttes and the Yellow Springs, a distance of sixteen miles, there is a series of low ridges, forming several anticlinals. The long walls of sandstone extend across the country northwest and southeast, inclining 30° to 50°. The sandstones are mostly of the age of the lignite tertiary, gray and rusty brown color, with all kinds of texture and modes of deposition.

About five miles west of the buttes a new formation appears of later date, the latter dipping 5° to 10° in the same direction, but not conforming to the older beds. Long ridges and benches extend down nearly parallel with the course of the Sweetwater, composed mostly of indurated argillaceous sands of a lighter color and less variable materials than the lignite beds. The high ridges around our camp are capped with a thick bed of quartzite sandstones, sometimes approaching a pudding-stone. West of Willow Springs we ascend a high hill covered with a thick bed of quartzitic sandstones in drift, and capped with the coarse sandstones. It is quite probable that we have been passing over the eastern rim of an ancient fresh-water lake, the rock materials of which are incidental with the trend of their deposits. Long high benches, composed of these beds, extend far southward as the eye can reach, parallel with the North Platte and the Sweetwater. It is plain that they jut up close against the sides of the ridge that borders the north side of the Platte, near the junction of the Sweetwater. Here and there the cretaceous or lignite ridges rise above the more modern deposits, always inclining at a large angle, showing unmistakable discordancy. Ascending an elevation of about four hundred feet, west of Willow Springs, we descend a long slope, into the valley of the Sweetwater, which, in some respects, is one of the most interesting geological districts I have ever examined in the west. There is a high ridge or divide between the drainage of Wind River, North Platte, and Sweetwater, three hundred to four hundred feet above the channels of these streams, which is composed of the tertiary beds. The Sweetwater forms a distinct concavity, with this high divide on the north and east, and the valley has been scooped out so that until we reach the Sweetwater Cañon, near the South Pass, only the massive granite ridges rise up among the modern tertiary beds which jut close up against their base. This is most emphatically a valley of denudation, over a space of at least thirty to fifty miles in width. All the unchanged formations, from the lignite tertiary down to the massive feldspathic granites, have been worn away, leaving the granites scattered over the valley in the isolated ridges. At that time there was a fresh-water lake which occupied the entire valley, much as Salt Lake once occupied the great basin, concealing most of the granite ridges, while others rose above the waters like islands. Then was deposited what might be called the Sweetwater group, or perhaps a series of beds identical with the upper portion of the Wind River deposits. These were scooped out again in time, and the pliocene marls and sands were deposited; and then again there was an other scooping out of the valley, and finally a covering the hills with drift. In the pliocene marls and sands are quite abundant remains of mammals, similar to those which are found on the Niobrara River, in Nebraska. The Seminole and Sweetwater mountains, although covered all about their flanks with tertiary beds, show, higher up, the elevated ridges of Potsdam sandstone and carboniferous limestones. The whole range is comparatively smooth and grassed over, as if it had been too high above the waters to have been affected to any extent by the later forces that scooped out the valley; so, too, the Sweetwater Mountains, or hills as they should be called, simply expose the Potsdam sandstone, carboniferous, red beds, with very small areas of the Jurassic, cretaceous, and granites. Indeed, the Sweetwater valley is a sort of anticlinal, with the Seminole and Sweetwater hills on the south side, and the divide between the Wind River and Sweetwater on the north. The northern portion of the anticlinal is seen only for ten to twenty miles near the Three Crossings, where the lower Silurian and carboniferous beds are shown over a restricted area. The numerous granite ridges which are scattered all through this valley are most probably remnants of a vast mountain nucleus, from which the unchanged rocks inclined on either side.

We pass over a level surface for the most part, through the deep sands, which are the result of the disintegration of the tertiary sandstones. Large areas are covered with the alkali efflorescence, so that they are white as snow. From Willow Springs we camped at Independence Rock, a noted landmark for travelers for many years past. I was anxious to understand the geology of this wonderful spot, and on that account was delighted to find my tents pitched at its base. The Sweetwater flows immediately along the southern end of it, although on the opposite side of the stream another ridge continues toward the southwest, which, I have no doubt, was once connected with it. Independence Rock is really one of the granite ridges in this valley, and is a remnant of much larger mountains. It now looks like an enormous boulder lying out in the plain. It is a vast but most excellent illustration of the theory of disintegration by exfoliation, for it is rounded and resembles an oblong hay-stack with the layers of rock lapping over the top and sides of the mass like the layers of hay on a stack. Thin layers have been broken off in part, and huge masses are scattered all around it; but on some portions of the sides they lap down to the ground with so gentle a descent that I was able to lead my horse nearly to the summit, about two hundred feet. Two sets of fissures are plainly seen in this rock, one set east and west and the other north and south.

The entire mass, as well as all the granite ridges in the valley, may be called feldspathic; that is, the red and white feldspar predominate, while the mica occurs in very small quantities. It is quite probable that the vast quantities of this alkaline efflorescence were derived from the decomposition of the feldspars. Stansbury gathered some of these salts, which he called "efflorescence from a saleratus pond," on Sweetwater river. Dr. Gale found them "to be composed of the sesquicarbonate of soda, mixed with sulphate of soda and chloride of sodium, and is one of the salts called Trona, found in the natron lakes in Hungary, Africa, and other countries." These salts are not perceptible to the taste in the water of the stream itself. The granite ridges south of Independence Rock, and on the opposite side of the Sweetwater, I estimated to be from one thousand to fifteen hundred feet above the bed of the stream. I ascended one of the loftiest of the ranges, with great difficulty, on account of the smoothness of the rocks and the abruptness of the sides. From the summit as far as the eye could reach in every direction granite ranges could be seen, of varying lengths, from one hundred to fifteen hundred feet above the surrounding plains. Far away to the southeast, dimly seen and overtopping all the rest, was a range of mountains which I suppose were the Medicine Bow range. All around the flanks of these granite ranges the same tertiary beds jut up without any interruption, and are smooth and even, so that the granite masses seem to rise abruptly out of the plains. In some of the broad intervals are the most beautiful terraces or benches, sloping gently down from the base of the mountains to the valley. Not a sign of water could be seen in any of these mountains at the present time. A few cottonwoods and groups of quaking asps, in some of the ravines on the sides, gave evidence that water issues from them at certain seasons of the year. A few stunted pines struggled for existence among the crevices, and some rare shrubs and ferns were all the vegetable life observed. It seems as though the Sweetwater flowed through this valley for fifty miles or more with scarcely a tributary to add to its volume.

These granite ridges present the finest opportunity for the study of rocks. Huge fissures, which have been enlarged by atmospheric agencies so that they vary in width from a few inches to several feet, seam and furrow their sides.

On the summits vast masses, of one hundred tons weight, appear just ready to topple down. Many of these fragments look like gigantic boulders, so rounded have they become by the process of exfoliation, and such they would be called if they could be transported from the tops of these mountains by water and ice to the prairies of Illinois, without any further change in their form. Some of these masses are now covered with thin scales or layers, which are ready to fall off, and multitudes of fragments are scattered around. Before leaving Independence Rock we endeavored to obtain an approximate idea of its dimensions. The circumference, measured with the odometer, is fifteen hundred and fifty two yards, and the barometer indicated the height of the north end to be one hundred and ninety-three feet, and the south end one hundred and sixty-seven feet. The trend of the mass is about northeast and southwest. There is a depression near the middle which cannot be more than sixty feet high. The huge fissures which pass through the rock in various directions seem to form channels for water, and remind one of a river and its branches. Although there is enough of red feldspar to give the whole a reddish tinge, yet the white or soda feldspar occurs in great quantities. Five miles up the valley we came to another well-known locality, the Devil's Gate, a cañon which the Sweetwater seems to have worn through the granite range. The road passes through a depression in the mountain which is about thirty feet higher than the bed of the stream, and I am inclined to believe that the Sweetwater once flowed through it, but for some reason, not very obvious, changed its channel. Perhaps the water found some fissure through which it began to flow, and gradually wore its way through, as we see it at the present time, or it may have vibrated its way from point to point. Now the stream flows between these lofty walls with a low, gentle murmur, which cannot be regarded as the roar of a torrent. Indeed, it gave forth a soothing music not common to mountain streams. The current is not strong, and finds its way among the huge masses which have fallen down from above without difficulty. The left wall is somewhat higher than the right. The cañon is about northeast and southwest, as if the waters had passed through a sort of dike fissure, and the northeast end shows the gate more perfectly, where the walls on either side are nearly vertical, and the width of the bottom is not more than one hundred feet. The southeast end is worn out to some extent, and is two hundred to three hundred feet wide. By the barometer Mr. J. W. Beaman made the right wall three hundred feet high, and the opposite one to be a few feet higher. In the gate or cañon is a wide dike or trap, which has a trend about northeast and southwest, in which the channel of the river may have started originally. At the present time the waters have cut across the dike so that the southeast portion still remains on the right side. These granite ranges are not unfrequently banded with old trap dikes, trending about northeast and southwest, and varying in width from a few feet to two or three hundred feet. Some of them yield quite readily to atmospheric agencies, and many conspicuous depressions are produced in the ranges, thus adding much to the picturesqueness of the scenery. These dikes are quite common in some of the ranges, and all have a peculiar black appearance in the distance; but the difference in texture is shown by the influence of the atmosphere upon them. Some of them stand up as sharp and angular as ever, but most of them have been so rounded off that the loose masses are nearly spherical, and the thin coats are falling off like the layers of an onion. Sometimes the materials are coarse, and the rock falls in pieces; again the mass is round and smooth, glistening like black opaque quartz. There is no evidence at the present time of the age of these dikes, except that the material was thrust up through the fissures in the granite. They may be of different ages or of the same age. We find they have been subject to the same erosion as the granite, and extend across the country in regular bands.

From the Devil's Gate we traveled westward along the bottoms of the Sweetwater to the "Cloven Peak," a conspicuous landmark for the traveler. On our right hand we were walled in most effectually by the granite ridges; on our left, in the distance, about fifteen miles, was the Seminole range, or hills, as I have regarded them in this report. They rise high above the surrounding country, but seem to have formed the south side of the tremendous erosive forces which once swept through this valley. The outlines of these hills are so different from any others that are within the range of vision, that they excite the attention of the observer at once. There are no ridges of upheaval along the flanks, as in the case of the Laramie range, but the grassy plains jut up close to them, and the very summits are, for the most part, rounded and grassed over. No timber clothes them, except now and then a group of poplars. The north side is very abrupt, while the south side slopes off into the plains. Near the Three Crossings there is a low point or pass in the hills which extends for about ten or fifteen miles, where a second range commences, called the Sweetwater Hills, and continues to the South Pass. The Seminole Hills rise about fifteen hundred feet above the Sweetwater Valley, while the Sweetwater Hills vary from eight hundred to twelve hundred feet. Near Cloven Peak, fifteen miles west of Devil's Gate, there are some high bluff banks on the south side of the Sweetwater, about one hundred feet high, which indicate the existence of quite modern tertiary beds, like those on the Niobrara River. They are composed of indurated sands and marls of a light-gray or cream color, and are in appearance precisely like those seen on the Laramie River, and many other places, which I have usually regarded as of the pliocene age. Still farther to the westward are numerous exposures of these beds, which are weathered into the usual fortification-like forms, and scattered around their base are large numbers of remains of extinct mammals and turtles, apparently identical with those found on the Niobrara. They occur in the same beautiful state of preservation. These beds are full also of oddly-shaped concretions of sandstones of all sizes. The sandy beds disintegrate very readily, and the bottoms, as well as the road, are made up of loose sand, which is readily moved by the wind, rendering traveling difficult. Indeed, the entire valley of the Sweetwater, below St. Mary's Station, is more or less covered with moving sands, the result of the disintegration of these pliocene beds. The appearance of the surface is similar to that seen on the Niobrara River and the head of the Loup Fork in Nebraska. I am inclined to believe that these pliocene beds are a deposit made subsequent to the somber brown indurated sands, and the conglomerate sandstone which forms the outer rim of the Sweetwater basin. The pliocene beds are best shown in the valley itself near the stream, while no traces of it were seen (on the high divide west) about the rim of the valley. The granites form the boldest and most barren-looking ridges I have ever seen; some of the peaks are true dome-shaped, and are apparently as smooth and as bare as a church dome. No water is to be found in or around them, and here and there a few stunted pines manage to extract a scanty nourishment from among the fissures. On our left the most magnificent benches extend down from the Seminole Mountains for ten miles or more. This range is smoothed and grassed over, and some portions are thickly covered with pines.

West of the Seminole Mountains is another detached range or group of hills ten to fifteen miles long, parallel with the Sweetwater; then near the Three Crossings there is another range, low and covered thickly with pines. Still farther west is another detached group of hills, which extend to the South Pass. These hills undoubtedly form the southern rim of the Sweetwater basin. I think this basin varies from thirty to fifty miles in width. In one of these detached groups of hills we can see a high ridge of limestone, with a strike northwest and southeast, while the group of hills trends about northeast and southwest. Near the Three Crossings the high granite ridges are on our right, and rise seven hundred to eight hundred feet above the bed of the Sweetwater. From the tops of the ridges, far to the westward, we can see the Wind River range, and feel the cool breeze that comes sweeping down the valley, ladened with the icy chill from the snow-clad summits. Small lakes are also visible in the plains, some of which seem to be fresh water, while all around the shores of others there is a thick efflorescence like snow. Far distant to the north and northwest there is another rim of this basin, which I have called the north rim or side. The granites near the Three Crossings seem to be somewhat peculiar. There are two principal sets of joints, one of which is horizontal and the other vertical, dividing the granite range into cubical blocks, and giving to the sides of the ridges somewhat the appearance of mason work. Sometimes the very compact feldspathic beds separate into columnar forms, which are quite picturesque. The peculiar mason-like appearance of the granite valley is entirely due to the vertical and horizontal fissures. This feature is more marked at this locality than at any other point we have examined.

On the 31st we made an examination of the lower range of hills which extend up to the South Pass on the south side of the Sweetwater. We found the granites occupying a very restricted area, and inclining from them a larger thickness of Potsdam sandstone with *Obolella nana* and a *Lingula*. Inclining against the Silurian sandstone was a massive bed of compact bluish and yellow limestone, with a strike northeast and southwest. At one locality I found the beds had been tipped past verticality 20°. The red beds were also shown here quite well developed. It would seem that the range of hills on the south side of the Sweetwater valley forms one side of the anticlinal, and the axis of elevation is not far from the channel of the stream. A pretty little branch with a considerable volume of water, and crowded with beaver dams, has excavated a valley near this point. It has a fork also, which is fringed with little cottonwoods, a feature quite unusual in the Sweetwater valley. Jutting up against the sides, and penetrating every valley or gorge in the outline of the mountains, are the brown indurated sands of the Wind River deposits; among them are impure seams of lignite or carbonaceous clay, with layers of coarse sandstone or an aggregate of particles of quartz. The disintegration of the harder beds has covered the surface with small fragments of rock. A little farther to the southward a huge hill, with almost vertical sides, is composed of light gray sands and worn crystals of quartz, with a thickness of from four hundred to six hundred feet. Here indurated quartzose sands have been weathered into most fantastic columns fifty to sixty feet high, giving to the group in the distance the appearance of white marble monuments in a church-yard. Much of the rock looks like the decomposed gangue of silver and gold lodes as seen in Colorado, that is, small fragments of quartz in a feldspar paste. On the side of this almost perpendicular hill, the summit of which is eight hundred to one thousand feet above the Sweetwater Valley, are enormous granite boulders of all kinds, gray and red feldspathic massive rocks. Not only the granites but also the sandstones decompose by exfoliation. In the brown beds are seams of rust-brown pudding-stone, which disintegrates on the low hills and in the valleys, covering the surface with small smooth pebbles and fragments of clay. This entire range of hills has the north side very abrupt and high toward Sweetwater valley, but the south side slopes gently down into the plains. I have no doubt that the nucleus of this range of hills is composed of the older rocks, as Silurian, carboniferous, or red beds, &c.; but, so far as we can see at this time, the modern tertiary beds seem to conceal them from view. Some of the valleys of erosion parallel to the hills show by the high walls a great thickness of tertiary beds. From the summits the eye extends far southward, fifty miles or more, over a most desolate, barren plain, with here and there a table-top butte to show that the surface was once much higher than at present. It is cut up into innumerable valleys, which give to the surface an irregular, wavy appearance. Not a tree or shrub greets the vision over this vast desert waste. The immense quantities of granite boulders, red and gray, which literally cover the tops and sides of this range of hills, must have been swept down from the Wind River Mountains. Some of these granite masses are ten to fifteen feet in diameter; others are sunk so deep in the earth that they appear to be in place. Across the plains, at least one hundred miles distant to the southwest, two or three low ranges of mountains or hills are visible. Toward the west end and on the north side of the range of hills I noticed a peculiar semicircular depression, about twenty-five feet below the summit, which affords an example of a land-slide on a large scale. This slide covers an area of about a mile in length and a fourth of a mile in width, and is covered with groves of the aspen.

Above the Three Crossings, on the north side of the Sweetwater, are several quite conspicuous granite ridges, but they soon disappear. Soon the beds of Potsdam sandstone, with carboniferous limestones and portions of the triassic, make their appearance, inclining at an angle of 20° to 30° northwest, and, in a short distance, pass beneath the Wind River deposits. We could not ascertain that any rocks older than the miocene tertiary beds occur along the northern rim of the valley from Willow Springs up to this point.

From the Three Crossings to St. Mary's Station the valley bottom of the Sweetwater is about half a mile in width and looks like a meadow, as usual. Our camp on the night of the 30th was near the point where the stream comes out of the first ridge. Hitherto it has flowed through an anticlinal valley, with the Sweetwater mountains or hills on the south side, and the granite ridges, capped with Potsdam sandstone ridges near South Pass. One of the most conspicuous features are the long benches that come down from the Sweetwater hills so regular, so high, and evenly rounded that they strike the eye at once. They are composed of modern tertiary marls, probably pliocene.

About four miles below St. Mary's Station the Sweetwater flows through a ridge of Potsdam sandstone with a trend nearly east and west, inclining north 75°. The rock is rusty, reddish quartzite, or an aggregate of particles of quartz. The Silurian and carboniferous rocks appear here and there, but the tertiary beds are the most conspicuous. Near St. Mary's Station the beds of conglomerate project out of the bluffs, on both sides of the Sweetwater, quite conspicuously. On the distant hills the arenaceous marls are much exposed in the form of naked hills, at the base of which Mr. Elliot discovered some very interesting turtle remains. About a mile above St. Mary's Station the Sweetwater flows out of a deep gorge or cañon, cutting the ridges of older rocks at right angles. The strike is northwest and southeast, dip northeast.

The limestones and sandstones are very conspicuous. On the north side we pass over the upturned edges of an enormous thickness for three fourths of a mile, inclining 30° to 40°. These ridges form the east side of the anticlinal that runs down from the Wind River Mountains. Indeed it is a portion of the range itself. So far as the east side is concerned I have never seen a more perfect anticlinal. The series of ridges of carboniferous limestones and Potsdam sandstones extends across the country in regular lines, and the erosion has been such that the outcropping edges are but little above the general surface, so that they can be studied with ease. The main road passes across the edges of all the rocks at right angles. Not far distant to the northwest the snowy peaks of the Wind River range rise high above the surrounding country. Here and there, resting upon the edges of the older rocks, are patches of the modern tertiary deposits, remnants of the last period of erosion. As we approach the base of the mountains there is a slight dip in these tertiary beds 3° to 5°, as if the last movements were subsequent to their deposition. There is a deep valley from the base of the mountains to the Sweetwater, which marks the line of separation between the Silurian and carboniferous ridges, completely separates them, but indicates no discordancy. Inside of these ridges is an immense thickness of slates standing nearly vertical, with a strike northeast and southwest, inclining slightly northwest. Extending to the northeast toward the Wind River Valley could be seen ridge after ridge of cretaceous and tertiary beds.

CHAPTER III.

FROM SOUTH PASS TO FORT BRIDGER.

Like the Black Hills of Dakota and the Laramie range, the Wind River Mountains form a complete anticlinal. It is so regular that when once the key to its structure is obtained it is studied with great ease. So far as my observations have extended, all the ranges with a northwest and southeast axis are simple and regular in their structure. They may be defined briefly as a nucleus of granite or gneissic rocks, rising step by step on either side toward a central axis, and on each side of the nucleus the various unchanged rocks inclining at a variety of angles. Sometimes extensive erosion and the subsequent deposition of modern tertiary beds or drift obscures the study, and we shall find that this is the case with the Wind River range. The Black Hills of Dakota is the most complete illustration of an anticlinal, not complicated by other influences, that I have met with in the West. The nucleus is massive feldspathic granite, with a series of gneissic beds outside of it; these incline in every direction from this nucleus, a sort of narrow, oval quaquaversal, and all the unchanged beds known in this portion of the west from the Potsdam sandstones inclusive to the top of the lignite tertiaries. The trend of the Wind River range is northwest and southeast. The portion in which the South Pass is located is about ten miles wide, and is composed mostly of metamorphic slates in a nearly or quite vertical position. It is in these slates that the gold mines are found. The gulch diggings are quite extensive, and although much has been done in that way, yet there is a most extended field open yet for the enterprising miner or laborer.

The facilities for placer mining are very great on account of the supply of water. The gold-bearing rocks are composed of thin gneissic slates, which occupy a somewhat restricted area about ten miles wide and twenty to thirty miles long. Some of the slates are very thin and might be made useful for building purposes; others are more silicious and fracture into columnar masses. Veins of white quartz run through these slates very frequently, and it is in these the gold is found. The most celebrated lodes in this district are the Cariso and "The Miner's Delight." The Cariso lode is about four feet wide; the shaft has been sunk one hundred and forty feet; the quartz yields $50 to $75 per ton. About $75,000 has been taken out of the mine by its owners. The lode has a strike northeast and southwest, and a dip of 70°. It was discovered in 1867, and has been worked two years. The lode itself is mostly composed of white quartz with some iron pyrites, while the country rock consists of gneiss. It will be seen at once that the great value of these ores lies in the ease with which the gold can be extracted. I shall describe these mines more in detail in a subsequent portion of this report, and simply allude to them now in their geological relations.

The elevations, as taken by Mr. J. W. Beaman, are of some interest. At "St. Mary's Station," on the Sweetwater, 6,590 feet. Ascending from ridge to ridge for ten or fifteen miles, 6,894, 7,149, 7,356, 7,405, and 7,524 feet, a gradual ascent, and probably approximately correct. At Fort Stambaugh the elevation is 7,714 feet; Atlantic City, 7,666 feet; South Pass City, 7,857. At Washakie's Camp, at the base, main range 8,158 feet, and the high ridges below the central ridge, 10,215 feet. This central portion of the South Pass district, or the area occupied mostly by the metamorphic slates, I have estimated at ten miles in width and twenty to thirty in length. The surface is somewhat rolling, but cannot be called rugged, and bears evidence of remarkable erosion. In many places long lines or rounded elevations extend across the surface like the ripples of a lake. The surface has been so worn down by erosion, and the irregularities filled with a heavy drift deposit, that these ridges or outcropping edges just project above the surface. Usually the surface is well grassed over, and in the valleys of the streams large quantities of hay are obtained. The timber consists principally of groves of aspen here and there, which give a beautiful appearance to the scenery.

September 1.—We arrived at Fort Stambaugh, and by the kind permission of Major Gordon, the commander of the post, pitched our camp near a fine spring, three hundred yards below the fort, and about three miles from Atlantic City. This post was named in memory of a gallant officer, Lieutenant Stambaugh, who was killed by Indians not far from this place during the past year. It is finely located in one of the most romantic spots in this region, surrounded by high hills, with beautiful groves of aspen on their sides. Springs of pure water are abundant.

September 3.—We left our camp at this locality, with a small pack-train, for a short trip to the Wind River Mountains; our direction was northwest about ten miles, across the metamorphic slates, until we came to the foot-hills; here the granites prevail. At first they have a fissile structure to some extent, but soon become massive, like the granites of Sweetwater Valley, except that the feldspar is white. The mass of the Wind River Mountains is gray granite, with here and there some red feldspathic seams; but as I found it in 1860, when crossing the range near the source of Wind River, to the head of Lewis' Fork of the Columbia, the central mass is mostly gray granite and wonderfully uniform in texture. Small masses of black gneiss are distributed through the granite. After entering the foot-hills we moved up the valley of one of the various branches of the Sweetwater, through most rugged scenery, among thick pines and over vast quantities of broken rocks or debris. At last we reached a high ridge which forms the divide between the waters that flow into the Sweetwater and those of the Sandy, and near this ridge, at an elevation of over 10,000 feet above the sea, we had a complete and near view of the Wind River range. Far above us rose the snow-capped ridges of the axis of the range, with Frémont's and Snow Peaks full in view. Frémont has given in his report the elevation of Snow Peak, which is probably the highest of the range, as 13,570 feet. One of the peculiar features of these mountains is the dense growth of a kind of "nut-pine," which furnishes food for innumerable birds and squirrels, and supplies the Indians with their favorite food.

Washakie's band of Shoshones had been up in the mountains only a few days before, and hundreds of the trees had been cut down for the nuts. I should judge that the limits of arborescent vegetation is about 11,000 feet. On the south side of the range there is not much perpetual snow, only here and there a patch; but on the north side snow-banks are extensive.

From this high ridge we had a most remarkable as well as instructive view of the southwest side of the range. Far out in the plains the long parallel ridges of the white tertiary marls could be seen, then step by step the ridges of granite rising to the summit. The outline of these granite ridges revealed most clearly the anticlinal character of the range, their sharp summits pointing toward the snowy crest above them. On the east side of the anticlinal the outcropping edges of a high ridge of carboniferous limestone extend down toward the Sweetwater near St. Mary's Station. The Silurian and carboniferous rocks form a conspicuous wall on the east side; on the west side, far up to the head-waters of the Sandy, they seem to be concealed by modern tertiary deposits. Not only the sides of the lower ridges, but the top and sides of the central mass are covered so thickly and continuously with fragments of granite that this becomes one of the most conspicuous features. Both Snow and Frémont's Peak are one mass of debris. During the day Mr. Jackson, with the assistance of the fine artistic taste of Mr. Gifford, secured some most beautiful photographic views, which will prove of great value to the artist as well as the geologist. We made our camp at night near the foot of Fremont's Peak, by the side of a spring of the purest crystal water, surrounded with a thick growth of fresh green grass, that gave a manifest delight to our animals. We were on the Pacific slope, and as the waters of the little spring passed by us, within a few feet of our camp-fire, in the stillness of the night, we imagined we could hear in its rippling music the faint echo of that of the great ocean to which it was hastening. Among the numerous plants which grew here, many of them with handsome flowers, I was attracted by the great abundance of a species of trifolium, with a white blossom, about the size of our domestic red clover of the States. There was also a large species of allium which I have not observed before in the West.

Although the geology as well as the mineralogy of the Wind River range is very simple, yet we turned our backs upon it with regret. I shall always retain in view the hope that I may yet be permitted to spend several months in this interesting range, so prepared that I can work out its topography as well as geology. In studying these mountain systems, the geology is the anatomy, and we must have the topography with it to clothe the skeleton and give it an expressive form.

On our way up the valley we passed several saw-mills which belonged to Mr. W. N. Hinman, of Atlantic City, one of the old pioneers of the Far West. Thirteen years ago I met him near the base of Laramie Peak, where he was engaged, as director of a saw-mill, by the commanding officer at Fort Laramie. His experience in the Rocky Mountain lumber business has been more extensive than that of any one else, and from him I obtained some valuable information. He informed me that the Rocky Mountain pines made lumber of about average quality; that the trees were of young growth, from two to three feet in diameter; that the boards dress smoothly and easily, and endure well, and are mostly free from pitch. The lumber can be produced at about $50 per 1,000 feet. He always explores the ravines and cañons on the north side of the mountains for the large tall pines, while on the south side they are liable to be scrubby and knotty. The agricultural capacities of this mountain region do not differ materially from those of the mining districts of Colorado. The grazing is excellent everywhere. Potatoes, turnips, peas, beans, and all kinds of garden vegetables that do not require a long season grow remarkably well in the valley of the Wind River, and are produced in considerable quantities at the present time.

At the time of our visit here Washakie's band of the Shoshones was encamped in the valley of one of the branches of the Sweetwater, where it emerges from the foot-hills of the mountains. Through the kind aid of Major Gordon, Mr. Jackson was able to secure a remarkable series of photographic views of these Indians and their camp in their native haunts. Most of the views have the Wind River Mountains as a background, and also show the women and children as they are naturally distributed about the village. I regard this series of views as a real contribution to Indian history.

On the morning of September 5th we left Fort Stambaugh, and followed the old emigrant road toward Fort Bridger. We had received every attention, and much assistance that was of great value to us, from the gentlemanly officers of the post. To Major Gregg, the quartermaster, we were especially indebted, not only for many social courtesies, but for that kind of aid which is so indispensable to our success, and which it is in the power of that officer to grant. Major G. kindly caused all of our wagons to be repaired, and furnished abundant supplies for our animals and ourselves.

West of South Pass City we cross over gneissic slates that dip northeast 10° to 25°. A little farther on we come to granites which incline in the same direction. Near the crossing of the Sweetwater are thick beds of reddish feldspar and white quartz imbedded with the gneiss. The white quartz extends across the country in bands, about northeast and southwest. The quartz seams in the massive granites are quite conspicuous, and trend in the same direction. The dip is southwest 20° to 30°. The granites and gneisses continued nearly to the Pacific Springs. The massive granites intercalated among the stratified gneissic rocks are the same in color and texture as those forming the central mass of the Wind River range, and I regard them as all of sedimentary origin.

South Pass is a gradual elevation, like a divide, between the streams to the plains. Indeed, the whole country is an elevated plain, gently undulating, and the traveler passes the true divide or line of separation between the valleys of the two oceans without observing it.

On the evening of the 5th we arrived at Pacific Springs, one of the sources of the Sandy, a branch of Green River, a long, low, boggy piece of ground full of springs, and a notable camping place for emigrants. We have spoken of the low ridges of granite and gneiss, which are distributed here and there along our route, from South Pass to Pacific Springs. Scattered over this surface, forming the water divide or pass, and filling up the irregularities, is a superficial deposit of modern date, probably pliocene, which once covered the area occupied by the metamorphic rocks in considerable thickness. This deposit is composed of drift underlaid by yellowish-white arenaceous marls, with greenish clay. Wells are dug near Fort Stambaugh through a great thickness of this light marly clay, which is undoubtedly the result of the decomposition of the feldspathic granites. Just west of the pass we have several hundred feet of these modern beds, which form long parallel ridges, with rather marked naked white surfaces, evidently denuded of vegetation, by the perpetual winds that sweep down from the northwest. Extending nearly east and west, or northwest and southeast, and inclining gently to the south and southwest, is a broken ridge seven hundred feet above the springs, capped with a bed of coarse, rusty sandstone, evidently of modern age. This ridge is covered over with huge granite boulders of various textures, which seem to have come from the northeast. Just south of the ridge is a still higher one, with strata horizontal, and so denuded that the surface resembles "bad lands," with red, indurated arenaceous clays at the base, rising up into light yellow marly clays, weathering into the usual fantastic forms. The highest point to the southward is Table Rock, or Steamboat Buttes, as they have been named by the emigrants, rising high above the surrounding plains, a monument to perpetuate a portion of the former thickness of the middle tertiary formations in this region. The strata are nearly horizontal, and must have reached a thickness of one thousand feet or more, extending over the country far to the south and southwest toward the railroad. I regard the western side of the Wind River anticlinal as the eastern shore of the second series or lower miocene tertiaries, which reach all over the basin drained by the Green River and its tributaries, southward to the junction of Henry's Fork. The northeast side of the shore line is very steep and abrupt, inclining slightly, 3° to 5°, covered with immense granite boulders, but little worn, which evidently came from the Wind River range. The white and yellow marls and clays rest on the metamorphic rocks, are of pliocene age, and they extend far to the northwest, parallel with the range. The same formations occur near the Three Crossings in the Sweetwater Valley, and are rich in remains of extinct mammals, similar to or identical with those of the Loup Fork group. The reddish or India ocher clays, with leaden gray bands, form the base of the lower miocene group. Above them is an extensive series of yellowish marls and rusty-drab limestone, filled with a species of *Bythinella*, *Viviparus*, and other fresh-water shells, with silicified wood. One of the peculiar features of the lower clays, near this shore line, which does not occur farther inland, is the numerous seams of small rounded pebbles, held together loosely with fine sand. As we descend the valley below Pacific Springs it soon expands into a broad meadow, which yields a vast quantity of hay. Winding through the meadow is a fine stream of water, which increases in size continually from springs until it unites with the Sandy. On the Little and Big Sandy the formations are like those near Bryan and on Green River, and on the denuded hills the remains of turtles were found. At our camp on the Big Sandy, September 7th, we caught the best view of the Wind River mountains we have yet seen. As the morning sun shone on them and scattered the mist and smoke from their summits, they seemed not far distant, and loomed up along the horizon with a sharp, clear outline, that rendered the view most grand and imposing. Frémont's and Snow Peaks were clearly defined, and the series of sharp peaks that project from the main ridge seemed to diminish in height far toward the sources of Green River. In no country in the world, it seems to me, can such a comprehensive view be presented to the eye at a glance as at this point, where it can take in one of the loftiest of the ranges which form the main chain of the Rocky Mountains, stretching along the horizon for at least one hundred and fifty miles. I could not ascertain that any of the older sedimentary rocks are exposed along the western side of this range, from the South Pass to the sources of Green River. Ridges of the lower miocene tertiary strata along the western limit of the metamorphic rocks form an unmistakable shore line of the ancient lake. Between this shore line and the foot-hills of the mountains is a belt of metamorphic slates and gneiss, covered here and there with pliocene marls. The erosion all along the western side of the mountains has been tremendous, sweeping down in a northeast direction to the Sweetwater Valley. In a preceding chapter I described the Sweetwater Valley as one of erosion, on a most remarkably grand scale, and that the Sweetwater and Seminole Hills formed the south side of the anticlinal, and that the north side is seen at the present time only in fragments here and there, most of it having been swept away or concealed by the Wind River deposits. I am also inclined to believe that the Sweetwater Valley is only an extension to the east or south of east, of the axis of the Wind River range.

From the Big Sandy to our camp on Black's Fork, near Granger Station, we passed over the Green River beds, capped here and there with ridges of the leaden-gray, indurated arenaceous clays of the Bridger group. In the Green River beds are quite abundant remains of reptiles, as *Crocodilus Elliotti*, and the fragments of fishes, *Unios*, *Melanias*, *Paludinas*, *Planorbis*, &c., and found in the lower miocenee, and *Unios*, *Lymneas*, and remains of turtles and mammals in the Bridger group. On either side of our road we can see in the far distance a high ridge or table-top butte, like the Pilot Buttes which the erosive forces have passed by as remnants of the old surface. Among the rugged hills along the Big Sandy, and in many other localities, are long cylindrical concretions, which look much like silicified wood. They form the central portions of high, rusty-drab concretionary sandstones, and on exposure the sandstone exfoliates from the brown silicified interior, and the latter breaks in pieces, oftentimes in sections, which show the most perfect concentric rings, like the layers of growth in wood, with cavities filled with chalcedony. Most beautiful specimens can be obtained of what appears to be a thin, woody, exterior shell, covered with bark, and lined inside with beautiful crystals of quartz or chalcedony. Similar concretions occur in the Wasatch group near Piedmont, on the railroad. It is not surprising that Stansbury (see Report, p. 72) should have mistaken these singular concretions for silicified trunks of trees, which they very closely resemble. All over the surface, and especially on the tops of the hills, are distributed immense quantities of partially-worn flint rocks, which come from the debris of these concretions. It is from these rocks that the masses of chalcedony, as well as the "moss agates," have their origin. Along the railroad and about Church Buttes the surface in many places is literally paved with small fragments of a dark-brown, shiny, flinty rock, somewhat worn, among which the "moss agates" are found; all these rocks originate in the Bridger group.

We found our camps on the Sandy Creeks and Green River very pleasant, with abundant grass for our animals. The bottoms are usually quite broad, and though covered with the white alkaline efflorescence so common to this country, the soil has all the elements of extreme fertility. Indeed this entire Green River basin, which seems to the eye so utterly desolate and barren, would produce all the crops that the climate will permit, most abundantly, if it could be irrigated; and the time may yet come when this apparently desert region may "blossom as the rose." Whether this state of things can ever occur or not, it is sufficient for me to state, that the soil, whether upland or lowland, contains in greater proportions the elements of fertility than that of Salt Lake Valley, which has been found so wonderfully productive.

The 10th and 11th of September we camped on Black's Fork near Church Buttes, and spent the time most industriously and successfully, exploring the remarkable "bad lands" for fossil remains, as turtles, mammals, and fresh-water shells, of which we gathered great quantities. Mr. Elliott made a fine series of panoramic sketches and sections, and Messrs. Jackson and Gifford procured seventeen beautiful photographic negatives of the most rugged portions of this unique scenery. The materials for the illustration of the different groups of strata are very complete, and will add greatly to our knowledge of the geology of some of the most interesting regions in the West.

On the evening of the 12th of September we arrived safely at Fort Bridger, the western terminus of our present explorations.

CHAPTER IV.

FORT BRIDGER AND THE UINTA MOUNTAINS.

On the morning of September 16 we left Fort Bridger for the Uinta Mountains, under the guidance of Judge W. A. Carter, whose long residence at Fort Bridger and intimate knowledge of the surrounding country proved of great value to us in our explorations.

Our course was a little east of north, across the plateau divide between Black's Fork and Smith's Fork. A distance of six miles from Bridger we crossed over the interval to Little Cottonwood Creek, a branch of Smith's Fork, and passed up that valley to the foot-hills of the mountains about seven miles farther. The valleys of these streams are broad and exceedingly fertile. The soil is a rich vegetable mold, and all the vegetation reaches a luxuriant growth. Large areas have been under cultivation by Judge Carter for years. Wheat, oats, barley, and all the roots, can be raised here in great abundance and with ease. Hay can be obtained in the meadows or damp places in unlimited quantities, and the grazing cannot be surpassed. That portion of the country between Fort Bridger and the foot-hills of the mountains may be divided into bottom land and table land; that is, the bottoms are very broad, varying from two to five miles in width, and the table lands are sort of terrace divides, which look in the distance as level as a table top, and descend very gradually from the foot-hills. These plateaus are covered with sage at this time, but every acre of them could be cultivated by irrigation, and the soil is as fertile as any of the fruitful lands of Salt Lake Valley. The miocene beds of the Bridger Group jut up against the sides of the mountains in a nearly horizontal position. Up among the foot-hills I found the bones of a turtle, the teeth and jaws of a mammal, and an abundance of fresh-water shells, of the genus Planorbis. I am now inclined to think that the long high ridges that extend down from the flanks of the mountains between each main stream or its branches, are composed of modern tertiary beds. Still they are so smooth and so thickly grassed over, and covered with groves of pine and aspen, that I could never find a locality where the rocks were exposed, so that I could obtain a connected section. The surface is covered very thickly with rounded boulders of reddish sandstone and quartzite, with some masses of carboniferous limestone. The ascent is very gradual, and the roads excellent, almost to the summits of the range, at least to an elevation of 11,000 feet above the sea.

Both Smith's and Black's Forks separate into numerous branches, and between each one is a lofty, precipitous ridge, which extends down from near the summit of the mountains in the form of steps or abrupt points. Pheasant Point and Porcupine Point are examples of this kind. It is a curious fact, however, that none of these ridges ever reveal their interior character, being clothed with a dense growth of pine and aspen, or in the open places, on hill or in valley, thickly with grass and a deep soil. For ten miles at least not a trace of the basis rocks could be found in the channels of the streams. Spruce Ridge, between the sources of the Muddy and the valley of Bear River, revealed the fact that there is an immense deposit of drift covering a belt along the flanks of the mountains from ten to twenty miles in width, extending in some places nearly to the crest of the range. The upper portion of this drift is composed of fine arenaceous clays, covered with a deep, rich, vegetable soil. It therefore sustains a luxuriant vegetation up to an elevation of nearly 12,000 feet. The mountain rises in steps, because there are ridges of elevation; hence, Judge Carter has given this range the appropriate name of "Terrace Mountains."

Thus we have two kinds of ridges; those of elevation, which are parallel with the axis, and those of erosion, which are parallel with the valleys of the streams, and radiate from the axis at right angles to the ridges of elevation. The first locality, between Smith's Fork and Black's Fork, that we observed rocks in place was at Photograph ridge; a lofty upheaval of carboniferous limestone, inclining at an angle of 40°. The elevation of the crest was determined by the barometer to be 10,829 feet. This ridge extends across Black's Fork, with a trend about northeast and southwest. From this ridge to the axis of elevation there is a series of sandstone ridges, passing gradually into red and gray quartzites. These ridges rise, like steps, to the crest of the range.

The first ridge is composed of dull, purplish sandstone of various degrees of texture, from a compact sandstone to a pebbly conglomerate. The quantity of broken rocks and debris is wonderful, rising like a wall one hundred to two hundred feet high. Then comes a broad, grassy valley and a second ridge of sandstone, though a portion of this ridge is covered with the drift deposit, so that the sandstones are seen only in the sides of the valleys of Smith's and Black's Forks. The inclination of these sandstones is about 35° northwest. At the foot of the ridge next to the crest of the mountains there is a broad valley like a plateau. This has the appearance of an elegantly prepared lawn, so thickly and evenly is it covered with grass. It is 11,869 feet, and 1,100 feet above the limit of arborescent vegetation. This also forms one of the radiating ridges, which extends down from the axis of the range to the plains, and separates the valleys of Smith's and Black's Forks. Sometimes it is several miles in width, but toward the crest of the range the ridge of separation is not more than two hundred yards wide. Standing on either side of this ridge, the view that meets the eye toward the sources of these streams can hardly be surpassed for ruggedness and picturesque beauty. The valley of Smith's Fork seems to be altogether one of erosion, cutting through the uplifted strata nearly at right angles. The beds are well shown in the sides of the valley for miles, inclining at angles from 20° to 35°. At the very sources of both Smith's and Black's Forks are pyramidal or conical peaks most distinctly stratified, and apparently horizontal, or nearly so, with the summits above the limits of perpetual snow, and from fifteen hundred to two thousand feet above the springs that give origin to the streams below. These peaks or cones are vast piles of purplish compact quartzite, resembling much Egyptian pyramids on a gigantic scale, without a trace of soil, vegetation, or water. One of these remarkable structures stands out isolated from the rest, in the middle of the valley of Smith's Fork, which we estimated to rise fifteen hundred feet above its base; and so much like a Gothic church did it appear, that the members of my party gave it the name of Hayden's Cathedral.

From Carter's Plateau I descended into the valley of Smith's Fork, and after traveling about three miles over ridge after ridge of sandstone and quartzite, inclining at various angles from 20° to 30°, I came within a short distance of the base of this cathedral, when I found that it formed the south side of an anticlinal, and that the trend of the valley was northeast and southwest. It would seem that while all the beds on the north side of the anticlinal dip at a large angle, those on the south side were forced up in a nearly horizontal position, inclining southwest only 3° to 5°. The valley is full of little lakes, which form an interesting feature of the scenery of the Uintas. In most cases they are the result of land-slides, and occur at different elevations, depending upon the conditions that bring them into existence. Carter's Lake is a beautiful sheet of water, inclosed on one side by a semicircular wall of purplish sandstone and slates, and on the other by a dense growth of spruce trees. The depression for the accumulation of the waters of this lake was formed by an immense mass of rock sliding down from the ridges above. The side of the mass opposite the ridge from which it was detached would be the highest, forming a rim for the depression. Springs of water ooze out of the sides of the ridge, snows melt, and the waters flow down and gather here, and soon a little lake is formed. This one is three hundred and fifty yards in length, and eighty yards in width.

It is quite plain that these slides have been the chief agency in enlarging these valleys, for even at this time we see the evidences of it everywhere, both at the head of Smith's and Black's Fork. The valley extends from half a mile to a mile above the anticlinal valley, and in the dry season of autumn, far above the existence of water. I am inclined to believe that the origin of the stream and its valley began in this anticlinal opening, and that the valley has extended up above it by the sliding down of vast masses of rock which were swept downward by the waters. On the west side of the valley of Smith's Fork, near its head, is a vast semicircular notch or indentation, nearly half a mile deep, which has been wholly formed by these slides. In the valley below, which is five hundred to eight hundred feet deep, are half a dozen lakes, occupying the depressions of these slides at different elevations. The day that we explored the valley, was quite warm, and the sides were covered with banks of snow twelve to fifteen feet deep, from the edges of which were flowing streams of water into these little lakes or pools. From the sides of the valley issued beautiful springs also, which contributed their portion. From these lakes flowed little streams, which gradually concentrated into the main channel of Smith's Fork. The same description will apply to the valley of Black's Fork, except that a portion of the east side seems to be formed of the sloping side of one of the inclined ridges of sandstone, thus showing that it is not altogether one of erosion. The west side reveals all the quartzites and sandstones in their regular order of sequence, for several miles, inclining at various angles from 20° to 40°. From the high peaks of the crest of the range we can look down the deep, almost straight valleys of Smith's and Black's Forks, southward into the plains, and follow the remarkably tortuous course of the little streams that flow down them. There are no real mountain torrents in this range, no picturesque waterfalls or narrow gorges; but the valleys are deep and wide, with almost vertical sides, eight hundred to twelve hundred feet high. Yet the lower portions below the quartzitic belt are covered thickly with trees or grass, so that the underlying rocks are concealed. The fall of the water is so slight in the streams that they are not only exceedingly tortuous, but frequently accumulate in little lake-like expansions, which add much to the beauty of the scenery, especially as the waters glisten when the morning sunlight falls upon them. In a volume entitled "Sun Pictures of Rocky Mountain Scenery," illustrated with photographs, I have included two views, taken at the head of the west branch of Bear River, by Mr. A. J. Russell, as types of Uinta Mountain scenery. Sun pictures No. 1 and No. 14 exhibit Moore's Lake with the quartzite mountain in the background. The stratification can be seen perfectly. This work, though very costly, can be found in most of our public libraries and can be referred to by those who may be interested in the scenery of the Uinta Mountains. Mr. Jackson, photographer to the survey, has taken a large number of views in this range, illustrating every variety of form which the texture of the rocks would admit of, in the process of erosion or weathering. These views, I hope, will be given to the world in some form at no distant day. As studies of the geological and geographical features of the country they will prove of great value, and their fidelity to nature cannot be denied.

We descended the dividing ridge between Black's and Smith's Forks by the same road we passed up, but nowhere below Photograph Ridge did we see any of the rocks underlying the drift. I am confident that, could the immense deposit of drift be stripped off, we should find the regular series of formations, as triassic or red beds, Jurassic, cretaceous, and older tertiary, and possibly coal-beds. Yet so thick a deposit of drift and modern tertiary covers the sides and foot-hills of the range that these formations do not probably affect the outline of the surface. It is quite certain, however, that they will be found cropping out somewhere, even on the north side of the range, or perhaps on the south side in the Uinta Valley. I regret very much that my time would not permit me to make a thorough exploration of both sides of this most interesting range. Some problems which now are obscure might thus be made plain

TRIP TO THE HEAD OF BEAR RIVER, UINTA MOUNTAINS.

We left Fort Bridger on the morning of the 24th of September, with a small pack train, and pursued a north course up the valley of

Black's Fork for fourteen miles. This is a beautiful and fertile valley, varying from three-fourths to a mile in width. Every foot of the bottom land could be cultivated with ease, and Black's Fork would supply an abundance of water for irrigation. The soil, like that of all the valleys of the Uinta range, is a rich black vegetable mold, which always sustains a heavy growth of native vegetation. The creek itself is fringed with a handsome border of cottonwoods and aspens; spruce and pine come in, which, mingled with the deciduous trees, give a pleasant variety to the foliage. Each of the streams that flow down the slopes of the Uintas separate into numerous branches, and between each branch there is a dividing ridge which extends down from the mountains and breaks off abruptly at the base. The Bridger group extends up to the base of these ridges and juts up against the foot-hills. Then come the grass-covered and woody ridges, which are composed of strata of yellow and green arenaceous clays, with thin layers of sandstone projecting from the sides. The grass and other vegetation covers the surface so uniformly that it is difficult to find a connected section of the strata, but it is probable that there are lower tertiary beds, which form a portion of the coal series.

Leaving Black's Fork we ascended the dividing ridge westward to Muddy Creek, and followed an old trail just under the foot-hills of the mountains. The elevation of the summit of the ridge is 7,857 feet. This ridge is most beautifully diversified with groups of aspen trees. The surface is covered with loose water-worn rocks, mostly the red sandstones and quartzites that must have been drifted from the crest of the mountains. On the west side of this ridge is a singular table-top butte, with an elevation of 7,977 feet, and five hundred feet above the waters of the Muddy, which flows along its western base. It is evidently a fragment of an upheaved ridge of middle tertiary strata, inclining from the mountains at a small angle. The southwest side is very abrupt, and the strata are exposed so that a moderately good section can be studied. The summit is covered thickly with water-worn boulders, which seem to have lodged there on their way from the Uintas. The deposit of drift is at least fifty feet thick, and the greatest accumulation of the boulders is on the abrupt edge toward the ranges. Below the drift are alternate layers of light-gray argillaceous limestone, sandstone, and laminated arenaceous clays. In one of the upper beds of limestone is a thin seam of black chert or flint, with fresh-water shells, and plants. A thickness of two hundred feet of the base of the hill is composed of arenaceous clays with a light pinkish tinge, which is peculiar to a vast series of beds west of the rim of the basin. From the top of this butte the view is very extended in every direction. To the south are the Uinta Mountains, with the foot-hills or ridges gradually sloping down into the plains, covered with aspen groves and pines, with here and there grassy, meadow-like openings. To the west and north, as far as the eye can reach, thirty to fifty miles, we see only the modern tertiary beds. These all show a slight inclination from the range, with the southwest side of the projecting ridges abrupt and denuded, and the northeast side sloping gently down and covered thickly with grass. On one of the little branches of the Muddy the carboniferous limestones crop out somewhat obscurely, but sufficient to show that they exist underneath this vast deposit of drift and tertiary strata. I have no doubt that the entire series of unchanged beds known in this region, either do exist or have existed on the flanks of the Uintas, although at this time they may have been eroded away. We know that along the railroad, near Aspen Station, the cretaceous rocks are brought to the surface, and in the valley of the Weber the Jurassic, triassic, carboniferous, &c., are enormously developed. We then ascended the west branch of the Muddy, along one of the most beautiful mountain valleys we have yet seen. It is quite narrow, inclosed between high ridges, the sides descending in step-like slopes to the stream. The little groves of aspen were distributed over it with the most delicate artistic taste, and the varieties of autumn coloring of the foliage surpassed every power of description. One could look for hours upon them, and yet there were no marked salient points, and the charm consisted more in a kind of esthetic feeling which no pen or pencil can portray. The grass is excellent, and the water pure from mountain springs. The sage shrub grows very rank, which also indicates the fertility of the soil. We camped in a little grove of aspens, and all the party were so well pleased that they united in calling it Camp Elliott, in honor of the artist of our expedition. The elevation was ascertained to be 8,194 feet. The next morning, September 25th, we continued up this branch of the Muddy for about two miles, and then struck across the divide to the west branch, and followed that up to Spruce Ridge, the high divide between the waters of the Muddy and Bear River. Here we caught a full view of the range of mountains, with the sharp peaks covered with snow. This was just the point we had desired to reach where we could take a careful survey of the country, and determine our point of destination. I had with me a most excellent field glass, and so useful have I found it in my explorations that it has become my inseparable companion. With it I could extend my vision over a vast area. Far to the northward, one hundred and eighty miles distant, the white snow-clad mountains of Wind River were distinctly visible extending along the horizon. The intermediate space resembles in its surface the irregular broken waves of a sea. To the west, not more than fifty miles distant, the Wasatch range can be clearly seen, while the beautiful broad valley of Bear River and its branches are spread out beneath us. It is difficult for one to fully appreciate the wonderful extent of country over which the eye can travel through the pure atmosphere in this open country without having visited it. It seems to me that no other portion of the world can present so much surface of country to a single grasp of the vision. Spruce Ridge explains so much that has hitherto been obscure in regard to the foot-hills of the Uintas, that I will describe it more minutely.

Smith's Fork, Black's Fork, and Bear River take their rise in the main divide of the Uinta range among the snow peaks. Each one of these streams has its smaller branches, which originate from springs issuing from the lower foot-hills. Between Black's Fork and Bear River is the Muddy Creek, which drains a broad valley, and separates into half a dozen branches, most of which extend up to the main range. The range itself consists of a central belt or zone of peaks and ridges, more rugged and inaccessible than most mountain ranges. This belt varies from five to fifteen miles in width, and has a general trend about east and west, or northeast and southwest. Below this zone, the mountains are composed of step-like terraces or ridges, which are so covered with drift material, and sustain such a growth of grass and timber, that the basis rocks are seldom if ever exposed to the eye. Thus we have two kinds of ridges—the ridges of upheaval, which incline away from the central axis and are parallel with it, and the ridges of erosion which radiate down into the plains from the rugged belt before described as forming the crest of the mountains. Spruce Ridge extends from this central belt with a somewhat irregular outline down into the plains between the drainage of Black's Fork and Bear River. All along the sides of this ridge, nearly to the summit, thousands of beautiful springs of water gush out, and, concentrating in some valley, form quite large streams, and really are the main sources of these rivers. Sometimes these ridges are only a few feet in width at the summit, as between the waters of the Muddy and the east branch of Bear River. Here a little further up the mountain it expands out to a width of four to six miles, and is covered with large forests of pine and aspen groves, with meadow-like openings, varying in size from fifty to one thousand acres each. Then again, to the sources of the main branches near the mountain crest, these ridges become very narrow, merely separating the waters of the streams. Upon these ridges are trails or roads, made by men or wild animals, which lead one with comparative ease up the rugged mountain divide. Spruce Ridge is formed of a great thickness of drift conglomerate. This consists of quite large masses of purplish and gray sandstone, quartzites, and carboniferous limestones with fossils, with now and then a granitoid or gneissic rock. The boulders are not usually large, varying in size from a small pebble to two feet in diameter. The rocks are mostly the purplish sandstone, quartzites, and limestones from the carboniferous ridges. These rocks are more or less water-worn; some of them are quite angular, as if they had not been transported far or rolled in the waters, others are much rounded. They are set in an arenaceous pudding-stone paste, mostly decomposed feldspar and quartz of a grayish-white color. The whole mass is not closely cemented and yields readily to atmospheric agencies. The entire thickness of this modern deposit, as shown by this ridge, must be very great, from four hundred to eight hundred feet. It, however, varies much in thickness in different portions of the range. I have mentioned the different kinds of rocks in this ridge from the fact that such deposits are almost certain to contain specimens from all the geological formations which come within the scope of the agencies which deposited it. I have found by experience that I can anticipate the existence of nearly all the rocks of different formations or those of different ages, in a mountain, by examining the drift materials distributed over the base or foot-hills of the range.

This ridge also presents a marked illustration of the influence of landslides in shaping the surface of the sides of this range. These slides are doubtless caused by the numberless springs which ooze out of the sides at every point of elevation from the plains to the main divide. They also give the peculiar, terrace-like, or step-like character to the slopes which has suggested the name of "terrace range" for these mountains. These steps are usually very gradual and smooth, but in some cases they give an extreme ruggedness to the surface. The east side of Spruce Ridge is nearly vertical for two hundred feet or more, and the conglomerate beds project out of the sides in horizontal layers. The east side is very steep, but slopes down to the plains without any very abrupt break, and is covered with grass or forests of aspen or pine; but the west side is covered, as far as the valley of Bear River, with a series of abrupt steps, which would appear to be of comparatively modern date or of different dates within our present period. These landslides, on the west side of this ridge, extend a width of three to five miles before reaching the east branch of Bear River; and from the summit of this ridge we had a most excellent opportunity to study the effects. An immense mass of the drift conglomerate has slipped off from the ridge and fallen down; the detached mass opposite the main ridge is the highest, forming a sort of sharp, low ridge, sloping toward a depressed center; thus a depression is made for the accumulation of waters from the drainage of a small area; and thus others—most of the little lakes that have given such celebrity to these mountains—have been formed. Carter's Lake, a most beautiful little sheet of water at the head of Smith's Fork, is formed in that way; it is about three hundred yards long, and fifty to one hundred wide. These little accumulations of water occur at all elevations from the foot of the mountains to the crest; and in looking from the high mountain divide, down the valleys of Bear River or Black's Fork, they appear like gems set in the landscape as their waters glisten in the sunlight. In many instances these little lakes are surrounded with tall pines, which cast their shadows across the waters with such sharp outlines that they have become favorite subjects for the photographer; thus we have the beautiful pictures of "shadow lakes." I have described this ridge more in detail from the fact that it supplied me with a key to an important portion of the history of this curious mountainous range which was before very obscure.

I think the Uinta Mountains might be divided into three belts or zones, parallel with the axis: 1. The tertiary beds at the base lapping on the sides of the foot-hills for a short distance; 2. A broad belt, fifteen to twenty miles in width, covered with a vast deposit of drift, and so covered with vegetation, and so smoothed down to the water's edge of all the streams, that the basis rocks are entirely concealed from view, and it is only by the accident of a land slide the character or extent of this modern drift deposite can be ascertained, but inasmuch as it has given the most prominent surface feature to this range it is worthy of our careful study. The third belt comprises the central portion, which is covered with sharp peaks rising eleven thousand to twelve thousand feet above the sea, varying in width from ten to twenty miles. This is the most rugged and inaccessible portion of the range, and is composed of high ridges of upheaval, parallel to the axis of elevation, and the strata inclining from it. These three belts will be described in detail as we proceed from point to point.

Leaving that portion of the ridge that separates the waters of Bear River and Muddy Creek, we passed along a sharp crest to a broad, sloping, plateau-like area between Black's Fork and the east branch of Bear River. We thus see at a glance that not only the greater part of the water of the main streams that issue from the mountain originates in this second or middle belt, but that some of the important streams are entirely fed from springs that flow out of these grassy or wooded slopes. In ascending the "plateau slope" above mentioned we pass around the fountains of half a dozen branches of Muddy River, which in the plains become quite important trout streams, varying from ten to thirty feet in width. As we passed up this ridge toward the water divide, sometimes it would expand out three to five miles in width, with thick forests of pine or broad, meadow-like openings covered with a thick growth of grass. Then it would become so narrow that we could look into the magnificent, gorge-like valleys of the rivers on either side. The surface is covered thickly with transported rocks, mostly of reddish sandstones and quartzites of the mountain nucleus. We made our camp in the edge of the spruce forest, at the upper side of a beautiful grassy meadow of about one thousand acres in extent, near a fine spring, ten thousand three hundred and eight feet above tide water. The sky was clear and the weather mild. We slept on the ground in the open air with a satisfaction which we shall not soon forget. Our animals drank the mountain water and cropped the sweet, nutritious grass as delighted as ourselves. We were about ten miles in a direct line from the axis of elevation. The course of Black's Fork is nearly north, while the branches of Bear River flow northwest. Our camp was within a few hundred yards of the west bank of the valley of Black's Fork, and from the margin we obtained a most instructive view of the third or central belt. The west side of the valley of Black's Fork is very steep, rising from eight hundred to one thousand feet above the channel. It is covered very thickly with transported boulders, most of which are but little worn. Here and there are quite broad terraces, produced by land-slides. On the opposite side are the high ridges of limestone which have been furrowed down the sides by atmospheric forces in a somewhat striking manner. The color and general appearance of the mass across the valley led me to believe that it was the result of an outburst of igneous rocks, but on closer examination I found it was an extension westward of Photograph Ridge from Smith's Fork, and was composed of limestones of carboniferous age. About two miles further up the west side of Black's Fork we came to an exposure of the red-beds or triassic, the first display of them I have been able to find in the mountains. They are shown here from one hundred and fifty to two hundred feet in thickness, passing into grey sandstones quartzites and indurated arenaceous clays; then alternate thin beds of gray limestone and sandstone, and finally into the massive limestone that forms one of the most conspicuous ridges. The inclination of the beds appeared to be 46° northwest, with a trend northeast and southwest. The red-beds being composed of yielding sands and clays, are here worn away so that a low, narrow pass was formed across the ridge between the west branch of Black's Fork and the east branch of Bear River, revealing the beds of sandstone and gray quartzites, the vertical layers projecting above the general level like walls, and their height depended upon the power of the rock to resist the atmosphere. Further up toward the sources of these rivers, where the strata are finely exposed, we could see clearly that the limestones formed a ridge of upheaval parallel with the axis of the mountains, and extend off far to the southwest across all the branches of Bear River toward the Wasatch range.

Among the numerous fossils that occur here in the limestones are *Zaphrentis*, *Productus Pratteniamus*, &c. Some of the layers of an ashen-grey, compact limestone were mostly composed of fragments of remains. The fossils, therefore, fix the age of the limestones that constitute this ridge there, beyond a doubt. The same limestones undoubtedly extend all over the Utah basin, along the western side of the Uintas, along the flanks of the Wasatch range and about Salt Lake. Many of the fossils appear to be identical with those from Salt Lake, described by Hall in Stansbury's Report. The succeeding series of rocks I have not found it so easy to locate in the geological scale. They consist of dull, purplish sandstones, with a series of thin layers of slate and clay, gradually passing down into quartzites. The upper beds are nearly all sandstones of various degrees of texture; some very fine and compact, others an aggregation of small worn particles of quartz; then a complete pudding-stone, consisting of water-worn quartz pebbles set in a silicious paste. As we proceeded toward the crest of the mountains, the sandstones are very clearly shown in the sides of the valleys of both Black's Fork and Bear River. As these diminish in importance, the quartzites increase until the beds of reddish and gray quartzites are very thick and massive, while the sandstones and slaty clays are thin and unimportant, until we arrive at the main divide, where the rocks are reddish quartzites alone. Between the east branch of Black's Fork and the east branch of Bear River the ridge is not more than one hundred to five hundred yards in width for a distance of three miles in a straight line. In this distance are ten or twelve ridges of upheaval which both valleys cut at right angles. Each ridge contains a massive bed of quartzite, which in some cases rises to a great height, and between the alternate ridges is a thin series of slates and sandstones, which, yielding more readily to the atmospheric agents, have been worn away, forming a narrow depression or pass from one valley to the other.

At the head of the streams the rocks that form the divide seem to have been elevated in a horizontal position, and they exhibit the most remarkable architectural forms as cones, pyramids, castles, cathedrals, &c. The strata are clearly shown, and are perfectly horizontal in most cases, sometimes inclining slightly to the southwest. Nowhere else in the West have I ever seen rocks assuming these peculiar forms. The scenery has an artificial appearance, so uniformly regular is the shape of some of the pyramids. These rocks most effectually shut off all water communication between the north and south side of the Uinta range. The distance from the red-beds or triassic, including the carboniferous limestones, to the crest of the mountains, I estimated at five miles in a straight line, and the inclination varies from 40° to 75°. In all this series of strata, from the red-beds to the oldest quartzites, I was able to detect no unconformability. The connection of the sandstones with the carboniferous limestones was perfect, so far as could be ascertained by the eye, whatever may have been the chasm in time. Not a trace of a fossil was found below the limestones, although I strongly suspect the purplish sandstones to be of Lower Silurian age. The texture of the upper beds of sandstone is so much like the Potsdam sandstones, as may be observed in other portions of the Rocky Mountain region, I was lead to suspect that the upper portion might be Lower Silurian. The section along the valley of Black's Fork is clear, inasmuch as the rocks are cut through at right angles to the strata and they all present an unbroken series from the oldest quartzites exposed to the carboniferous limestones; and close to the oldest quartzites are thin beds of sandstone, apparently unchanged or only partially so, and resembling in texture and color the upper sandstones, which I am inclined to regard as Silurian. I have estimated the entire thickness of stratified rocks exposed here at ten thousand feet. If this is true, about eight thousand feet consist of the sandstones and quartzites rising to an elevation of over twelve thousand feet above tide-water.

I am inclined to believe that the upper beds are Silurian, that they pass gradually down without any break in the sequence of time to rocks of Huronian age. The purplish quartzites are almost precisely like those which occur at the Sioux Falls in Dakota, and at the Pipestone quarry, in color and texture, which Professor Hall regards as Huronian age. At any rate, I have never observed such a series of rocks in any other portion of the West, and am inclined to think they are confined to the Uinta range. The Uinta Mountains are not far from the Wasatch range, and apparently join on to that range; yet I have passed through the Wasatch range at right angles at different points, and was able to discover no such series of strata. The precise or approximate age of these rocks is a very interesting problem to me, and I regret that my time will not permit me to make a more thorough examination of the range. A careful study of the southern slope, and the intermediate country southward into the Uinta basin, might afford some clue to their age, but I suspect that there are no fossiliferous strata in the series.

As I have before stated, two of the main branches of Black's Fork and Bear River take their rise in the axis of elevation at precisely the same point, run parallel for about five or six miles and then diverge, the former running north toward Fort Bridger, the latter northwest. Both have carved out for themselves wonderfully deep and picturesque valleys. They can hardly be called gorges or cañons from the fact that the sides are not usually vertical. In some places there are large semicircular indentations in the sides of the valley, caused by the sliding down of masses of earth; and in looking down from the plateau above, the eye meets with beautiful lakes, surrounded by small groves of pine or aspen. In the sides of the valley the strata may be studied with great clearness, usually inclining at a greater or less angle. These valleys are largely those of erosion, but not entirely so. The waters in former times have cut through a vast thickness of strata at right angles, but a portion of the way the valley lies between the ridges of upheaval, which I have termed monoclinals. Some of the smaller branches start in the monoclinal intervals, and flexing around northward cut through the ridge at right angles to the plains. In one instance a small branch of Black's Fork starts between two ridges of carboniferous limestones, wears out a valley eight hundred feet in depth and an eighth of a mile in width, flows a little north of east into the main branch, which runs about due north. At the same point commences a small branch of Bear River between the same two ridges of limestone, and flows a little northof west into one of the east branches of Bear River, although these two small branches run in opposite directions. The ridge of separation is not thirty feet above the principal valleys of Black's Fork and Bear River. There is another interesting feature just here which should be noticed. These small branches, four in number, completely isolate a large fragment of the limestone ridge. It rises up in the form of a cone eleven thousand feet above the sea, and seven hundred and fifty feet above the valley at its base. The inclination of the limestones is 45° to 50° northwest.

There are two important thoughts suggested by the study of this upper belt. First, the amount of debris found by the broken fragments of the sandstone and quartzites is immense, beyond any instance I have observed before. Not only the ridges, but also the sides of the deep valleys, are covered to an unknown thickness with fragments of quartzite, sandstone, and limestone, of all sizes from that of a pea to several cubical feet. Scattered over the surface of valley and ridges are also great quantities of the same rocks in a more or less worn condition, and the deposit of drift which extends up to the third belt, close to the crest, and varies in thickness from a few feet to 1,000 or 1,200, is composed to a great extent of these rocks. Along the northern slope of the Uinta Mountains, extending into the plains, these worn rocks cover an area at least one hundred miles in length from east to west and fifty from north to south. These stray masses are more worn, the further we recede into the plains northward from the mountains. In the region of Echo and Weber Creeks is a vast deposit of conglomerate, probably three thousand to five thousand feet in thickness, the most remarkable group of rocks of that character I have ever seen on this continent. The question has often arisen in my mind from whence the materials were derived. I cannot answer the question even yet, but the debris of the Uinta Mountains, if transported to some lake basin, would make a mass of conglomerate of equal thickness and cover an equal area.

The second thought suggested is the apparently excellent illustration of the gradual transition from unchanged to changed or metamorphic rocks. We have a thickness of about one thousand feet of carboniferous limestones unchanged. Passing upward to the crest of the mountains, but downward in a geological sense, we observe a series of purplish sandstones and slates, perfectly conformable to the limestones, and apparently unchanged. These sandstones gradually pass to thick beds of gray and purplish quartzites, which are exceedingly brittle in fracture, and plainly metamorphosed by heat. Intercalated among the beds of quartzite are thin layers of quartzitic sandstone and clay slate. As we proceed toward the crest of the mountains, where the rocks have been elevated from a great depth, the slates and sandstones become thinner until they disappear. I am therefore inclined to regard this as a remarkable example of the gradual transition of unaltered into metamorphic rocks. It would seem also that the finer the texture of the rock the more readily is it affected by metamorphic action.

On the morning of the 27th we descended from the high plateau into the valley of the small side branches of the east fork of Bear River, with the high, steeply inclined limestone ridge on the left, and the gray sandstone, and red argillaceous sandy clays on our left. The surface is so covered with fragments of rocks that the traveling is difficult. Our course was nearly due west for about three miles, when the valley flexes to the northwest. When we left our camp in the morning we were about two miles above the source of this branch. At our noon camp the little stream was two feet wide. For about ten or fifteen miles the stream flows between ridges twelve hundred to fifteen hundred feet above the valley, covered with pines and aspens, with no exposures of the underlying rocks. The same vast deposit of drift covers the valley and ridges all over the drainage of Bear River. As soon as we come out into the plains the valley expands to a width of several miles, and the tertiary beds jut against the foot-hills with a slight inclination from the range. Sulphur Creek is the most eastern part of Bear River, and rises in Spruce Ridge, flows northwest, and empties into Bear River near Bear River City. On the east side of Sulphur Creek, about two miles north of the railroad, there is a high ridge of sandstone one hundred to one hundred and fifty feet high, with an inclination of 20° to 25° west to northwest. It extends across the railroad a little east of north, and joins on to a range of hills, of which Medicine Butte forms a part. On the summit of this ridge is a layer of rusty brown arenaceous limestone, composed largely of a species of *Ostrea*. This ridge is the first indication of cretaceous rocks I have seen in the vicinity of the Uinta range.

From Sulphur Creek to the "rim of the basin," a series of modern tertiary beds are deposited unconformably upon the lower tertiary and cretaceous, filling up all the inequalities of the surface, and jutting up against the foot-hills of the Uintas. They are mostly horizontal in position, but sometimes dip 5°. This most characteristic feature is the light pinkish hue by which they are detected as far as the eye can reach.

In completing our section of the Uinta range and connecting it with the formations of the plains, the only period wanting is the Jurassic, no indication of which has been observed. The geologieal features of this region will be discussed more fully in a succeeding chapter, in connection with the belt of country along the line of, and contiguous to, the Union Pacific Railroad. The study of the Uinta range has been full of interest. It has been sometimes called the Alpine Mountain of America, though we miss the vast masses of snow and the glaciers; but in an artistic sense, no range that I have ever seen on this continent can compare with it in beauty. There is a far more rugged grandeur about the Wind River, the Sierra Nevada, or the Coast ranges; but in none of them is there such simplicity of structure, nor the contrasts so pleasing to the eye.

As I have before stated, there seem to be three belts or zones of country which one passes over in traveling southward from Fort Bridger to the crest of the Uintas. 1. The modern tertiary formations which jut up against the foot-hills, and are so denuded as to present to the eye an arid, naked appearance. We then pass suddenly to the second belt, which we ascend by a continued but almost uninterrupted ascent to an elevation of over eleven thousand feet. The lower portion of this zone is covered to a greater or less extent with groves of aspen, mingled with the spruce and pine. As we ascend the aspens cease and the pines become more dense. Here and there we find most beautiful meadow-like openings, with springs of water and a luxuriant growth of grass. Some of these meadows occupy two thousand acres. Looking down from some high peak across the belt, these openings meet the eye continually, and contrast most beautifully by the tawny color of their autumn dress with the dark, sombre foliage of the pines. The great luxuriance of the vegetation reveals the fertility of the soil. The third belt, which forms the crest, contrasts again by the almost entire absence of vegetation or water and the excessive ruggedness of the surface. In no other portion of our continent have I ever seen such types of scenery. Cones, pyramids, domes, and cathedrals, sometimes as sharply cut as if they had been wrought by art, occur at the sources of all the streams that rise in the anticlinal fissure.

The height of Gilbert's Peak, at the head of Henry's Fork, was ascertained by Mr. Beaman, with the barometer, to be 13,182 feet. Cox's Peak, at the head the middle branch of Black's Fork, rises like an immense dome above the surrounding country, 13,250 feet above tide-water. Dawe's Peak, on the dividing ridge between the west branch of Black's Fork and the east branch of Bear River, sends its sharp cone-like summit still higher, 13,300 feet. Logan's Peak marks the source of the middle branch of Bear River and is 13,250 feet above tide-water. All these are covered to a greater or less extent with perpetual snow. From a higher ridge that extends from the crest on the west side of the Uinta range there is one peak still loftier than any of those named, which we estimated to be 13,500 feet.

Nearly all the important streams that flow from either side of the range have their origin within a short distance of each other. From the summit of any of these peaks we can see the sources of them all at a glance. Looking at this range from the Union Pacific Railroad, or from Fort Bridger, thirty-five to forty miles distant, there is a very great difference in the clearness with which the summits can be seen at different periods of the year and upon different days. Sometimes, as the early sunlight falls upon them, they appear so near, through the clear atmosphere of this region, that they seem almost within our grasp. Again they are obscured with clouds or fog and are so faintly visible that they appear as a dim outline on the horizon.

An interesting feature in connection with this range is the limit of arborescent vegetation. On the north side of the range we determined the highest point, where low trailing shrubs grew, to be 10,769 feet, and estimated 10,500 feet as the limit of upright trees. As we ascend above this line the pines begin to dwindle until they trail upon the ground, and exhibit all the symptoms of a desperate struggle for existence, and finally disappear entirely. As we pass above the borders of upright trees, the stunted pines gather in groups, sometimes not more than four to six feet in height, forming the most unique but scraggy forms. In one instance about twenty of these trees formed a complete circle, inclosing a clear space of about fifteen feet in diameter; the tops, leaning toward the center, made a complete shelter. I gave it the somewhat poetical name of the "Uinta's Bower." At the extreme limit the groups of pines spread out along the ground, and always toward the east, showing that the winds in these mountains are mostly from the west. The pines and the aspens constituting nearly all the tree vegetation of the mountains, it becomes an interesting matter to determine the highest limit of the growth of the latter also. Observations with the barometer near the sources of the Muddy Creek showed the highest limit at one point to be 9,623 feet; at another 9,302. Probably an average of the two observations would be the correct one. There is considerable variation in the extreme limits, on account of the difference in position in relation to the sun. A southern exposure is most favorable, and, in consequence, the limit is extended upward.

I will not close my description of this interesting region without a word in regard to its future prospects. Judge Carter has introduced a bill into Congress asking for a charter for the Fort Bridger and Uinta Mountain Railroad, extending from some point on the Union Pacific Railroad, up the valley of Smith's or Black's Forks, to some point toward the sources of these streams. He also asks the very moderate grant of the alternate sections of land for four miles on each side of the road. It would be hardly possible for Congress to refuse a request which would be of such inestimable value to this portion of the country. Besides, it would bring into market eventually at least one hundred thousand acres of agricultural, grazing, and timber land for the Government, which would otherwise remain undeveloped for an indefinite period of time. In the valleys of Smith's and Black's Forks and their branches are thousands of acres of very fertile land, which could not fail to be occupied by the farmer; and all the intervening plateaus, comprising many thousands of acres of equally fertile soil, could be made fruitful by irrigation. By means of this railroad the vast quantities of timber and wood that cover the slope of the mountains would be accessible. Millions of feet of timber could be obtained for the Union Pacific Railroad at a trifling cost. The deficiency of wood for fuel over so great a portion of this country could be abundantly supplied from this source. As a summer resort for invalids, or those desiring rest from laborious duties, these mountains cannot be surpassed. Pure, clear, exhilarating atmosphere, ever-flowing springs of water, streams filled with fine trout, the woods stocked with all kinds of game, the most beautiful scenery in America, and the most accessible, offer attractions for all, and I am convinced that the time is not far distant when this country will be visited by thousands of seekers of health and pleasure. To the artist it would open a new world of beauty, supplying a variety and abundance of material for landscape studies which can be found in no other portion of the West.

CHAPTER V.

FROM FORT BRIDGER TO UINTA MOUNTAINS, HENRY'S FORK, GREEN RIVER, AND BROWN'S HOLE, TO GREEN RIVER STATION ON THE U. P. R. R.

On the morning of October 1st we left the hospitable post of Fort Bridger for the valley of Henry's Fork, about twenty-five miles to the southward. The principal portion of our party had remained near the fort since September 12, making repairs and recruiting our animals. In the meantime we had made most interesting explorations of the Uinta Mountains, the valleys of Smith's, Black's, and Bear Rivers, with their tributaries. We had obtained a pretty clear idea of the geology of the north slope of the Uintas and a part of the shore line of the Bridger basin and this gave us an earnest desire to trace it to Green River, to ascertain its connection with the "Green River beds," and the lignite or lower tertiaries. I take great pleasure in acknowledging here my great obligations to Lieutenant Shepard, the quartermaster of Fort Bridger, for numerous courtesies and favors which were indispensable to us, and which, in a country like this, money will not purchase. From Captain Clift, the commanding officer, and Dr. J. K. Corson, the surgeon of the post, myself and party were the recipients of many kindnesses. I have already spoken of my obligations to Judge Carter, to whom I was indebted for many favors and much valuable information. To him this portion of the West has been in the past, and will be in the future, more indebted for its prosperity and development than to all others. I take pleasure here in adding my testimony to the fidelity and truthfulness of his statements in regard to its resources.

Fort Bridger is quite pleasantly located in what appears to the eye a sort of basin inclosed by high, arid table lands, but really in a central portion of the drainage of Black's Fork. These beautiful valleys, Smith's, Black's, and Muddy, have been carved out the horizontal strata, and between the streams are terraces and flat table lands which give a singular as well as instructive outline to the surface of the country. No forces now in operation in this vicinity could have given the existing features to the surface of the country, and the cause must have been local, proceeding from the northern slope of the Uintas. The beautiful table-top divides between the valleys and streams are extensions into the plains of the radiating ridges of the mountain slope, and are literally paved, in many places, with the water-worn boulders of the purplish sandstones and quartzites, and with the carboniferous limestones that compose the nucleus of the Uinta range. Here and there we can see a flat-topped butte cut off by erosion from some of the intervening ridges and rising above the surrounding country as a partial witness to the extent of the denudation. A little south of west of Fort Bridger is an isolated butte called Bridger's Butte, which forms a prominent landmark to the traveler, and according to the barometer, rises seven hundred and fifty feet above the valley of Black's Fork at the fort. The summit appears perfectly level, and was estimated to be about two miles in length from north to south, and about a fourth of a mile in width from east to west. The upper portion of the butte is composed of the somber brown indurated arenaceous clays, grey and rusty brown sandstones of the Bridger group, passing down into limestones and marls of the Green River beds. In the brown clays are abundant remains of turtles, with a few fragments of other vertebrate remains. The terraces along the valley of Black's Fork are composed of yellowish and whitish-gray marls and chalky limestones, some of the layers mostly formed of Unios and other fresh-water shells. A few plants were found in the valley of Smith's Fork, in thin, black flinty layers, mostly ferns and leaves of deciduous trees. Between Fort Bridger and Henry's Fork the indurated arenaceous clays of the Bridger group are weathered into remarkably unique forms. The absence of harder layers of sandstone did not admit of the weathering into pinnacles, turrets, steeples, domes, &c., as we observe near Church Buttes. The surface, though very rugged and almost impassable except along the valleys of the streams, is much more rounded; the hills are more dome or pyramid shaped, and entirely destitute of vegetation, except the sage and several varieties of chenopodiaceous shrubs. As we passed up the Cottonwood Fork the marls and limestones made their appearance for a short distance in the bluffs. The divide between the drainage of Smith's Fork and Henry's Fork, is a high ridge of the leaden-brown clays of the Bridger group, which extends up and juts against the base of the Uinta Mountains. Passing over this divide we descended quickly to the valley of Henry's Fork, and camped near the point where it issues from the foot-hills of the Uinta Mountains, 29 miles southwest of Fort Bridger. This is a beautiful valley, quite broad, a large portion being meadow, and the surrounding hills, especially on the south side, covered with grass, rendering it a favorite place for years past for procuring hay and grazing stock. Hundreds of tons of hay have been cut and cured for winter use in this valley the present year. The time cannot be far distant when it will be occupied by settlers from its mouth nearly to its source. The view of the Uinta range from our camp was as beautiful and inviting as from Fort Bridger.

On the morning of the 2d I started up the valley with a small pack-train. The geology did not differ materially from that of the portions of the range already described. Up among the foot-hills is an isolated butte about three hundred feet high, capped with the brown clays of the Bridger group passing down into the calcareous layers of what I have termed Green River beds, containing an abundance of turtle shells, with teeth, jaws, and vertebra of some extinct mammal. These chalky limestones are also filled with large Planorbis in a perfect state of preservation. These beds along the flanks of the mountains have been slightly elevated or carried up in the later stages of the elevation of the range. They usually incline about 3° to 5°. The radiating ridge on the north side of the valley is covered with land-slides, which show a heavy deposit of reddish clays with narrow whitish bands, evidently a modern deposit, pliocene or quarternary overlapping the well-defined tertiary beds. These extend up a few miles and are again overlapped with the drift deposit described in the preceding chapters; the same dense groves of pines and aspens, the same open meadows, deep ravines, fallen timber, and great quantities of rocks on the surface occur, rendering traveling exceedingly difficult, which we have before noted. We passed the ridge of limestone into the belt of sandstone, with the lofty piles of debris, gradually ascending to the banks of perpetual snow, where the pines dwindle down and trail upon the ground. We rode our horses up to a point above the limits of arborescent vegetation, toward them, to a point 12,265 feet above the sea, and ascended to the summit of Gilbert's Peak.

We camped the night of the 3d in a beautiful open meadow, at the sources of one of the branches of Henry's Fork, 9,833 feet. The limestone or continuation of Photograph Ridge was 9,986 feet, while the valley between the carboniferous limestone ridge and the inner purplish sandstone ridge was found to be 9,453 feet. We found that the extreme limit of tree vegetation was higher here than farther west, 11,106 feet; and the point where the upright trees break off rather abruptly was about two hundred feet lower. As a general rule the trees dwindle in height to about twenty or thirty feet and then fall off abruptly to the trailing form, which usually extends up two hundred or three hundred feet higher in straggling bunches or groups. From the summit of Gilbert's Peak with my excellent field-glass I could look far over the surrounding country and study the principal geological and geographical features in their relations to each other. There are three main branches of Henry's Fork that rise in the axis of the range. The east branch has its source at the base of Gilbert's Peak on the northeast side and flows nearly north for ten or fifteen miles. The middle branch rises on the south side of the peak, flows west for a short distance, and bends around to the north. The west branch rises in the axis, runs parallel with the middle branch, with a sharp narrow ridge between them. All the branches of all the streams that flow down the Uinta Mountains from the quartzite belt cut the carboniferous limestone ridge at right angles on their way to the plains. At the southeast base rises one of the main branches of the Uinta River, runs east for about three miles, flexes southward or a little west of south, and flows down the southern slope of the range into the main Uinta. On the south side of this branch there is a rather sharp ridge, with six or seven conical points rising one hundred to two hundred feet higher than Gilbert's Peak, and culminating in a rounded, dome-like peak, which I estimated to be 13,500 feet. All the valleys of the streams that rise around this peak are more purely valleys of erosion than any I have seen in this range. The strata of Gilbert's Peak and the ridges and peaks in the immediate vicinity are nearly horizontal or incline southeast 4° or 5°. The principal peaks belong to the southeastern side of the axis. The two sides of the anticlinal are somewhat unequal. A narrow belt, comprising the highest peaks and ridges, with the curves, pyramids, and cones, seems to have been lifted up by forces acting nearly vertical, but the strata incline slightly to the southeast side, so that the streams that flow down the north slope of the range really extend their valleys a little past the anticlinal opening. At the sources of Smith's, Black's, and Bear Rivers the strata incline from the northwest side of this axis at a considerable angle. Here they incline slightly for about five miles, when they dip 20° to 30°. I have no doubt that these streams originated in this anticlinal opening, gradually cutting their channels through the beds of quartzite and sandstone at right angles. The quartzites as well as the sandstones are divided quite finely by joints, so that they break readily into cubical masses of moderate size. Besides they are very brittle, fracturing easily, as is shown by the vast amount of debris. Probably water accumulating in these fissures or joints would cause the debris to fall down into the anticlinal valley and be swept down the channels of the streams of the northern slope. This process of wearing away the horizontal quartzites from the northwest side of the southeast anticlinal has continued until some of the gorges extend up half a mile to a mile beyond the axis. In the beds of the branches of Henry's Fork the descent is by steps from one layer of quartzite to another down to the axis, like the horizontal layers of rock which form the rapids in many of our streams. At the present time there is seldom any great amount of water, in some cases none, above this axis; sometimes there is a little lake, the accumulated waters of the melting snows.

From this high elevation, with such a vast area of country within our range of vision, one could glance back into the abyss of time, and trace, step by step, the origin and slow erosion of these wonderful, gorge-like valleys, one thousand to twelve hundred feet deep, and speculate upon the beginning and growth of this beautiful mountain itself. The study of the northern slope of the Uintas has been such a source of pleasure and instruction, that I regretted my time would not permit me to examine the southern side also, but a glance over into the the Uinta Valley showed quite plainly that the southern side is nearly or quite the counterpart of the other. In all these valleys are numerous small lakes, which add greatly to their picturesque beauty. At the base of Gilbert's Peak, in the valley of the east branch of Henry's Fork, is one of the most beautiful of these lakes, which reflects the peak and the surrounding pines in its transparent waters. Mr. Jackson succeeded in catching a view of the peak and the lake, with the shadows, with his camera.

On account of its exceeding beauty and poetic surroundings, I have called it Lake "Annie." The barometer makes its elevation just 11,000 feet. This shows that the summit of the Peak is twenty-one hundred feet above the base at the head of this valley. We descended with great difficulty a sort of ravine on the steep sides of this valley to the bottoms, and followed the little stream from its source at the base of the peak to its junction with the main fork in the plains. As I have stated above, the strata of the peak are nearly horizontal, and for several miles down the valley the sides are six hundred to eight hundred feet high and nearly vertical, with the strata inclining at a very small angle. The bottom of the valley is full of the evidences of huge slides. Immense masses of rock seem to fall down gradually, something like the movement of a glacier, a certain distance each year, until they reach the channel of the stream, and the debris is swept down by the spring floods. Large semicircular notches in the sides or walls of the valley show most plainly how it has been enlarged in process of time. We passed on our way down the valley through a dense growth of pines and aspens, over boulders and among fallen timber, for about ten miles, when we passed through the gorge of Photograph Ridge, and came out into the wide, grassy, open foot-hills which led to our camp in the main valley of Henry's Fork, in the plains.

October 4.—We started down the valley of Henry's Fork to its junction with Green River. I have previously mentioned the ridge or divide between Smith's and Henry's Forks, which carries the tertiary beds up against the foot-hills of the range. From this ridge to Green River the valley of Henry's Fork forms a remarkable line of separation between the Bridger group and the lower miocene beds. This line of separation is somewhat of a surface one, yet it is so marked as to attract the attention of the commonest observer. The valley is quite broad, and on the south side the surface of the country to the summits of the mountains appear smoothed downward, in part grassed over. A close examination will detect some thin remnants of the Bridger group, underlaid by the lower tertiary beds, which have a tendency to weather into rounded, gently-sloping hills. On the north side, the arid, rugged, "bad lands" are very conspicuous, and rise up somewhat abruptly like a high wall. On the north side of the creek, there is a great thickness of the indurated clays which I have included in the Bridger group. All the divisions that I make are somewhat arbitrary. I can find no well-defined line of demarkation. There seems to be no unconformability, and the different beds pass from one to the other gradually; but to the leaden-gray, sombre, indurated arenaceous clays which cover a large area east of Fort Bridger and weather into such unique architectual forms, and contain a large variety of vertebrate remains, I have given the provisional name of the "Bridger group." These beds I shall also regard as upper miocene, and the calcareous layers which underlie the Bridger group are so well displayed lower down on Henry's Fork that I regard them as a portion of the Green River group and lower miocene. Below all these beds, is an immense thickness of sandstone and clays, which I group together as eocene, extending down to the cretaceous clays. Intercalated with the clays of the Bridger group are beds of rusty-brown and gray sandstones, all tending to a concretionary structure, and disintegrating by exfoliation in thin concentric layers. Sometimes there are beds of sandstone which form an aggregate of concretions. In the whole mass, arenaceous materials predominate. As we descend, the calcareous sediments prevail, until chalky limestones and marl are greatly in excess. The lower miocene beds are also of a lighter color. By the barometer the highest point on the north side of the creek is 8,583 feet. Our camp at the base near the creek is 7,615 feet, so that we have a vertical thickness of the tertiary beds of over one thousand feet. On the summit of the hill is a large accumulation of drift material, cemented with a calcareous cement into a coarse conglomerate. It is composed mostly of the sandstones, quartzites, and carboniferous limestones from the Uinta Mountains. These conglomerates are two hundred to two hundred and fifty feet in thickness, and are weathered into columns, sharp-pointed peaks, domes, &c., much like the conglomerates in Echo Cañon.

The summit of this high wall is a sort of table land covered with a deposit of fine reddish sand, plainly derived by erosion from the sandstones and quartzites of the Uintas. The surface is covered with grass, and slopes gently northward for several miles. From this high point I could comprehend to some extent the tremendous erosive forces that had been in operation here at a comparatively modern date. All the tertiary beds probably once extended uninterruptedly across the valley of Henry's Fork and jutted up against the sides of the Uinta range, and this immense deposit of conglomerate which caps the summit passed across and connected with the drift materials high up on the radiating ridges. It is an interesting fact that if we make a careful examination of the country we shall always find some remnants of the formations that may have existed, however great the erosion may have been. They seem to be left as monuments to aid us in reconstructing the surface as it really existed at different periods of the past; and this fact adds much to the charm of the study of the geology of the West. There is a slight inclination of the beds, which shows that they partook somewhat of the later movements of the mountains. As we descend, following the stream, we pass below the leaden-gray indurated clays of the Bridger group into a series of lighter-colored marls, with layers of laminated chalky limestone. These marls and limestones are somewhat arenaceous at first, but the sand diminishes and the lime increases in the descent. All the beds assume a lighter and more cheerful color, although there is some variety from rusty yellow to white. Henry's Fork flows about fifteen miles from its source nearly north, when it bends around a little north of east for about forty-five miles to its entrance into Green River. Most of the way it passes through a narrow valley about one-quarter of a mile wide, with abrupt, wall-like terraces on either side. These vary from eighty to one hundred and fifty feet in height. The bottom itself is quite pretty, covered with a thick growth of grass and large bitter cottonwoods. The grass in some places is six feet high and very thick. Hundreds of tons of hay are procured from this valley every season, and it is a favorite resort for herds of cattle and sheep in the autumn and winter. The soil is as rich as any in the West, being formed of the sands and clays of the Bridger group, with the calcareous materials of the Green River beds, as well as contributions from the limestones and quartzites of the Uintas. The mixture seems to be suitable for the production of a luxuriant vegetation under favorable circumstances.

At our camp, October 4th, the lower miocene beds rise up on the north side of the creek to a height of four hundred to five hundred feet. Near the base are layers of thinly-laminated slate, limestone, and some beds of cherty limestones with plants. There are also several thin seams of earthy lignite. There are several thin layers, especially near the lignite seams, which vary from an inch to six inches in thickness, composed mostly of small fresh-water shells, Melanias and Unios. These layers of shells continue nearly to the mouth of Henry's Fork, and masses of them are found in every ravine and creek. No experience of my own among fresh-water shells of the present day has revealed them in such marvelous profusion as they must have existed in or near this great lake in tertiary times. Intercalated in the marly layers are thin seams of fibrous calcite and selenite; some of the seams of calcite are three inches thick. Three principal features appear in the rocks as we descend the creek: 1. A large increase of lime; 2. Silica in the form of black chert or flint; 3. The appearance of impure lignite. There are also petrified wood, masses of stems of plants aggregated together, yet the beds are all purely fresh-water. The style of weathering of the upper and lower miocene is well contrasted by the character of the surface. The surface occupied by both formations is equally arid and barren, but that of the former is very rugged, forming what is usually termed "bad lands," while that of the latter is more rounded and far less rugged. At the junction of Henry's Fork with Green River the geological structure is very complicated and presents one of the most interesting studies I have met with on the trip. At first glance the formations seem to have been thrown into utter chaos, but a careful examination shows the system of formations to be more complete and consecutive than in any other portion of the West. The ridges of upheaval extend from the Uinta Range across Green River, and seem to have almost entirely escaped erosion, so that they are left for our examination nearly as they were thrown up by the internal forces that elevated the Uinta Mountains.

All along the northern slope of the Uintas, from Bear River to Henry's Fork, I have sought for the absent members of the geological series, and noted the evidences of erosions which are displayed on such a stupendous scale. Not only are several members of the geological series swept away, but also the surface is covered with an enormous deposit of drift. But not until we come to Green River can we realize the vast extent of the erosion along the northern slope of the Uintas.

About eight miles above the mouth of Henry's Fork the calcareous layers gradually disappear or cap the summits of the hills, and beds with a predominance of arenaceous sediments come in. Beds of massive yellow and gray sandstones rise above the water level as we descend, until they reach a great thickness, three hundred to five hundred feet. About four miles before reaching the mouth of the creek the valley expands out on either side. On the north side the upper portion of the bluff is a massive sandstone with a reddish tinge, inclining at an angle of 5° to 10°, while at the base the layers seem to have been pushed up abruptly, as if there was some degree of discordancy. The same beds that dip at a small angle on the north side of the stream incline 50° to 70° on the south side and extend southwest toward the foot of the Uintas. Then comes an open area of about four miles, occupied by rather soft beds of yellow and steel-gray indurated clays, which I have regarded as of cretaceous age, although I did not discover a fossil in them. On the south side of Henry's Fork, at its junction with Green River, is a remarkable exhibition of the ridges or hog-backs, which rise, ridge by ridge, to the distant summits of the quartzite nucleus of the Uintas. The formations at first sight seem to have been lifted up in such a chaotic manner that I could not unravel any system for some time.

We followed the channel of Green River down among the cañons, with the walls on each side rising twelve hundred to fifteen hundred feet, but only triassic and carboniferous rocks were seen. At last we found a deep dry gorge which had been worn through the ridges, on the west side of Green River, at right angles, thus exposing all the beds in their order of sequence, from the triassic to the cretaceous inclusive. In studying the section from the north side, commencing with the open area, which we supposed to be occupied with upper cretaceous clays, the first ridge is a yellowish-gray sandstone, inclining 35° west-northwest.

2. A series of steel-gray slaty shales, (No. 2 cretaceous section.) The usual scales and other remains of fishes are abundant, fixing this bed as positively lower cretaceous—one hundred and fifty feet in thickness.

3. The yellow-gray and gray sandstones of the lower cretaceous, (No. 1,) inclining 35°, two hundred feet.

4. A series of layers of remarkably variegated clays, with one of the layers of rusty sandstone.

5. A bed of fine gray sandstone, weathering brown, four feet, passing into clay, with a slight reddish tinge, inclining 30°. In these beds are some thin layers of siliceous limestone, mostly made up of a species of ribbed *Terebratula*, undoubtedly Jurassic, eighty feet.

6. Then comes about one hundred and fifty feet of alternate layers of fine gray sandstone and yellow gray arenaceous clay, dipping 50°. Jurassic fossils abundant.

7. A singular-looking series of variegating clays, about fifty feet thick, varying from a chalky white gray, ashen gray, light red, deep red, purple, in alternate bands; the colors giving a picturesque effect to the eye. They weather into curious rounded ridges, inclining 65°.

8. A thick bed, two hundred feet; grayish sandstone, weathering brown, inclining 40°.

9. A grassy interval, composed of soft beds, somewhat variegated, with thin layers of limestone, with *Terebratula*, *Ostrea*, and other Jurassic fossils. There is a considerable increase of lime in these beds. Just over these marls is a thick bed of somewhat laminated limestone, with fossils—fifty feet thick—dipping 26°. Above the limestone is another series of sandstones, marls, and clays, fifty feet thick, with thin layers of limestone, made up of Jurassic fossils. Then comes a series of sandstones, massive; a portion of them weathering with a reddish hue, forming a ridge, which rises one thousand feet above the channel of Henry's Fork, inclining 26°. Above this sandstone is a thin series, fifty feet, of alternate layers of sandstone, limestone, and argillaceous marls, with *Terebratula*, *Ostrea*, and other Jurassic fossils. This I regard as the upper line of the Jurassic beds.

10. The gray sandstone, weathering yellow, which form the upper portion of the triassic ridges, is very thick and massive. It is exposed here so as to be studied to the best advantage. I have never seen finer illustrations of oblique layers of deposition. The sandstone shows a vertical slice through it, one hundred feet or more, where all the irregularities are as perfect as possible. On the opposite side of the gorge the sandstone has an interesting cave in the side, at least fifty feet in every direction, and showing equally as clear the conditions of the deposition of the sediments. The cave is full of holes and crevices, which give shelter to multitudes of bats and other animals. Masses of their excrement project from the crevices, and sometimes run down the walls of the cave. In many instances this black excrement of bats has been mistaken for indications of petroleum. This cave has also been a favorite resort for Indians, as is shown by the fires, the walls of stone laid up for defense, the chipped flints and arrow-heads scattered about, and the rude images marked upon the walls. The sides of the ridge are very rugged and picturesque, weathered into a variety of architectural forms. The texture of the sandstone is quite soft, yielding readily to the atmosphere, and the valley is filled with loose sand. This ridge forms the di-

viding line between the triassic and carboniferous beds. It rises to the height of one thousand three hundred feet above the bed of Green River, which runs along its western base. Below the sandstones, well shown in the Green River cañon, is a considerable thickness of the brick-red arenaceous clays which I have so often described in former reports as characteristic of the triassic period in other portions of the West. These red beds pass down into a series of rather variegated arenaceous clays, with thin beds of sandstone and one or two beds of bluish siliceous limestone. The river sometimes flows for a short distance between the ridges, inclining in the same direction, or, as I have termed it, a monoclinal rift; then it cuts its way directly through a ridge, forming a narrow channel, with high vertical walls on either side; then making a flexure and taking a monoclinal valley again. I do not see that the waters made any difference in their course, whether they flow through a valley originally prepared for them or cut their way through ridges at right angles. The next ridge to the southwest of the triassic one is composed of limestones and calcareous sandstones of carboniferous age. These rocks in the aggregate really form but one of the ridges of upheaval, yet it is separated into numerous fragments, but without any distinct and continuous valley of separation, as between it and the triassic ridges. Then comes a series of ridges, of purplish sandstone and quartzites, reaching to the snow-covered axis of the range. The southwest abrupt face of the triassic ridges, at the entrance of Green River into the cañon, exhibits a remarkable example of the flexures of the layers, all the triassic and Jurassic beds forming a bow or arch. Pictorial sections were made of all the ridges, their surface, forms, inclination, and any local peculiarities. These are intended to be engraved for the final reports, and then my descriptions of this most interesting geological region will become more clear. From the summit of the triassic ridge, one thousand three hundred feet above the valley of Henry's Fork, we were able to gather within the limits of our vision a most interesting group of geological facts. This ridge is very tortuous in its outline, but its true trend is about southwest and northeast, parallel with the axis of the Uinta range. The angle or dip varies in different localities, but it is usually 20° to 30°. Taken at different points the strike of this ridge varies from east to west by way of north. At the junction of Henry's Fork with Green River the latter stream flows nearly east, yet it passes through this nearly at right angles. From the summit one can pass the eye over the upturned edges of an almost endless series of ridges across a rugged and picturesque surface. Far to the south the main range of the Uintas cuts off the view, while in the interval the ridges of sandstone and quartzite, with the usual thick growth of pines, rise like steps to the axis. Between the sandstones and the triassic ridge we look across the steep, jagged ridges of carboniferous limestones, inclining at various angles from 10° to 25°.

Not unfrequently, along the sides of the river where the channel passes through the ridges at right angles, the strata reveal very graceful curves or arches, as they pass down beneath the more recent beds. Looking west we can see how these ridges connect with the Uinta Mountains, and that without doubt all the northern slope of the range from Bear River was once as rugged and bristled with as sharp ridges as this portion on Green River.

We thus have some standard by which to estimate the extent of the erosion that must have occurred. The eye can run along the sandstone and quartzite ridges, and connect them without interruption far west toward the Wasatch range. The ridge of carboniferous limestone which crosses Green River to the southeast, though interrupted from time to time by portions swept away, is plainly a portion of what we have called Photograph Ridge all along the northern slope of the Uintas. The difference in the texture of the carboniferous rocks on Green River, and those forming the high ridges on Black's Fork and Bear River, indicates that the latter were partially changed by heat. The lofty triassic ridge facing Green River, from which we take this extended view, reaches off to the south of west, about fifteen miles, in full size, when it is broken into fragments and disappears on the surface. In descending the valley of Henry's Fork, we noticed a high fragment of a ridge to the south, rising about two thousand feet above the bed of the creek, which seems to have been cut off from the north side of Photograph Ridge, but is now so covered with drift that no sign of the basis rocks can be detected. The upper portion is covered with a belt of dense pines, and the remainder is smoothed down and covered with a good growth of grass. It is a beautiful ridge to the eye, without a sharp or angular point. I have no doubt that its nucleus is triassic. It is about fifteen miles in length, and breaks off quite abruptly, when the well-defined triassic ridge commences and continues in a somewhat tortuous line across Green River near the mouth of Henry's Fork. The only other indications of this ridge are the rather faint traces of it on Black's Fork and Bear River. The Jurassic and cretaceous ridges extend westward only five to ten miles, and disappear, not to be seen again until we reach Bear River and beyond. Intermediate between the lower cretaceous ridges and the lower tertiary beds is a broad, open, valley-like space, three to five miles wide, which is occupied by yellow and brown indurated clays. This valley-like space extends from the base of the Uinta Mountains, across Henry's Fork near its mouth, and over Green River in a southwest and northeast direction.

It would appear to have been a valley of denudation from forces having their origin in the Uintas. In this interval are numerous fragments of ridges which must have been once continuous, and which are now left to show the vast amount of rocky material which has been swept away. Over the surface is a considerable thickness of drift, composed of the well-worn boulders of sandstones, quartzites, and limestones which undoubtedly came from the Uintas. Still farther to the west, are the full series of miocene and tertiary beds, not less than three thousand to five thousand feet in thickness, extending to Fort Bridger and beyond.

If we were to extend this tremendous development of the geological formations from the quartzites to the tertiaries, as shown at Green River, where they appear to have suffered comparatively little erosion, all along the northern slope of the Uintas, far west to the Wasatch range, we should be doubtless reconstructing the former conditions of the surface; and we may thus form a dim conception of the tremendous erosive forces which have operated in this region. We may thus account for the vast thickness of drift and immense quantities of stray boulders which are scattered over the sides and foot-hills of the mountains far out into the plains. The further these worn rocks are found from the mountains, the smaller and more rounded they are, at once revealing the source from whence they came.

On the morning of October 8 we left our camp at the mouth of Henry's Fork taking a small pack-train for a three days' trip down the Green River to Brown's Hole. Crossing Green River we followed an Indian trail, which led us over the high ridge that forms the northern wall of the broad valley or hole at the junction of Henry's Fork with Green River. The general course of the ridge for the first thirty miles is about east to the lower end of Brown's Hole, where it seems to bend off south of east. After crossing this high triassic ridge our course was neary east, parallel with the river on the north side, thus passing diagonally across the different formations. We soon have on our left hand a fragment of the purplish sandstone, and outside of that a high ridge of carboniferous limestones, rising six hundred feet, and inclining 45°, with a trend about southwest and northeast. On our right were the ridges of the purplish sandstones and quartzites, rising step by step to the axis of the mountains, where the strata appear nearly horizontal, as at the source of Henry's Fork. Stunted cedars are quite thick upon the mountain sides, and for the first time this season we met with the "Piñon," (*Pinus edulis*,) or nut-pine, so common in New Mexico. The trail was a rugged one, leading over broken rocks, and up and down precipitous hills.

Brown's Hole is an expansion of the valley of Green River, and is about five miles wide and thirty in length. Just before reaching the main valley there is a small expansion called Little Brown's Hole. These are names given to these localities by the old trappers, forty years ago or more. Far north, in the mountains at the sources of the Columbia, are beautiful valleys of a similar character, called Pierre's Hole, Jackson's Hole, &c. These were all favorite wintering places for the trappers. But little snow fall in them, and they are so surrounded by high mountains that the bleak winds of winter can not reach them. Brown's Hole has been a favorite locality for wintering stock for many years, and the day we visited it, twenty-two hundred head of Texas cattle were driven into it from the east, to remain during the winter, and destined for the California market in the spring. It is covered with wild sage and chenopodiaceous shrubs, with scattered bunch-grass. A small number of cattle or horses could find abundant food for winter, but so large a number as were in it at the time we visited it must consume all the grass in a few weeks. The strata of red quartzite are distinctly shown on each side of the valley. It would appear that there had been originally a sort of monoclinal opening, the beds on the north side dipping northwest 20° to 30°. They present their upturned edges, therefore, to the valley, and here and there beds of gneiss and white quartz have been thrust up, sometimes to a great height, so that the sides of the mountains have a somewhat variegated appearance. At first glance I supposed some of the modern tertiary beds had been lifted high on the sides. On the south side of the valley the quartzites dip gently down to the eastern end of the wall, and apparently pass under the modern tertiary beds. In the process of erosion the waters have cut diagonally across the sides of the quartzite beds, so that they appear somewhat like the opposite side of the anticlinal; but I am convinced that it is an inner ridge, inclining originally in the same direction, and extended over a portion of the south side of the valley.

The gorge from which the Green River issues, near the mouth of Vermillion Creek, is very beautiful. The waters have cut a channel directly through the rocks, showing the layers most perfectly on each side, inclining at a moderate angle. Mr. Jackson was very fortunate in securing an excellent photograph of this cañon, which will express its geological characters perfectly. In this valley there is an extensive modern deposit, which I suppose to be of pliocene age. It is composed of beds of fine sand or very friable sandstone, light gray, yellowish gray, with brown sandstone in thin laminæ, &c. The whole deposit seems to be sand, with some mixture of clay, and weathering in the usual style of these deposits into rounded hills with deeply and regularly-furrowed sides or "bad lands," as the surface is usually called. On the summit is a thick bed of conglomerate, composed of the rocks of the mountains, purplish sandstones, quartzites, carboniferous limestones, and quartz. Toward the upper end of the valley this drift conglomerate is one hundred and fifty to two hundred feet thick, and becomes thinner as we descend.

Along the north side of the valley this drift deposit is quite thick all the way down, but it is scarcely seen in the immediate vicinity of the river. The tertiary beds jut up against the sides of the mountains, slightly elevated and inclining 3° to 5°. They were borne up to some extent during the later movements of the internal forces that elevated the mountains.

On the south side there are remnants of the tertiary beds, apparently perfectly horizontal. I have estimated these modern tertiary deposits to be six hundred to eight hundred feet in thickness. It is probable that Brown's Hole formed a sort of "bay," into which the waters of the tertiary lake to the west and southwest set up. These modern deposits are not uncommon among the mountain valleys. The Arkansas marls, in the valley of the Arkansas, similar deposits in the Middle Park, in the mountain valleys at the source of the Missouri, in Salt Lake basin, &c., are all, doubtless, of similar character and origin.

At one point on the north side of the valley, close to the base of the mountains, these beds are weathered into unusually beautiful architectural forms, like the ruins of pyramids, &c. They are usually smoothed off on the upper surface into table lands, but this one locality will strike the eye of the traveler at once as a style of weathering of unusual beauty and regularity. There is but little timber along the immediate valley of Green River—only a few bitter-cottonwoods and willows; but on the hills there is a thick growth of the low piñon and cedars. In the mountains above, as well as in the valley, there is a universal growth of the sage, (*Artemisia tridentata,*) greasewood, (*Sarcobatus vermicularis,*) and *Linosyris.* The sage grows to the height of eight and ten feet, and is sometimes six inches in diameter. There were some remarkable clumps of the *Rhus trilobata*, ten to twelve feet high, growing over the Green River bottoms.

On our return we passed out of Brown's Hole by way of the Henry's Fork road, as it is called in this country, which led us up the cañon of Red Creek. Here we have the largest display of whitish quartz that I have ever seen in the West. The sides of the cañon rise up eight hundred feet or more, massive quartz. At the entrance, one side of the cañon presents the appearance of a cathedral. This style of weathering, for quartz, is unique. There is here an outburst of old trap, and some beds of gneiss. There are also layers of true mica schists. The inclination is 60° to 75° northwest. The first quartz, gneiss, and trap that I have seen in connection with the Uinta Mountains occur at Brown's Hole, in this portion of the range. The Red Creek seems to wind its very tortuous way among the monoclinal rifts for about five miles, where the mountains cease abruptly.

As we pass up the Red Cañon the sides rise to the height of eight hundred to one thousand feet, composed of white quartz, with a remarkable number of intrusions of trap. The igneous matter has protruded itself into every opening or fissure, in every possible direction, sometimes between the strata and sometimes across them, in thin layers or in huge, branching masses. Most of the way for a distance of five miles these high, nearly vertical sides were spotted with the black trap, contrasting with the white quartz. Nowhere else have I ever seen such clear, well-marked exhibitions of the trap protrusions, and they deserved a much longer study than I could give them. I believe that this igneous material was protruded among the quartz beds prior to their upheaval. At the entrance of Red Cañon Creek from Brown's Hole the elevation is 5,897 feet, and very nearly the highest point of the range was 8,073 feet, and the bottom of Green River, about ten miles below, was 5,175 feet; so that by these elevations we may estimate approximately the heights of these mountains above the surrounding country.

As we emerged from the Red Creek Cañon, we came out into a sort of semicircular area, occupied by yellow-brown clays, the same as those occurring in a similar locality at the mouth of Henry's Fork. The northeast side of this quartz range is very abrupt, and no rocks appear to be exposed between the quartz rocks and the cretaceous. Red Creek runs through the widest portion of this semicircular area, about two miles on the south side. The ridges of cretaceous and tertiary soon close up against the sides of the mountains, and about four miles up a little branch of Red Creek, which flows parallel with the range between the ridges, the same beds jut up against the range in the same manner. The southeast wall of this semicircle is formed by a massive bed of tertiary (lower) sandstones, one hundred to one hundred and fifty feet thick, south of the Red Creek, dipping about 10°. The soft clays are shown under the sandstones for thirty to fifty feet in thickness.

As far as the eye could reach from the summit of the highest mountains these ridges of tertiary extend off ridge after ridge, each one inclining at a moderate angle, and having an open valley or space between, which seems to be composed of soft beds. We have, therefore, the cretaceous clays occupying the first open semicircular space; this is walled in by a ridge of lower tertiary sandstone one hundred and fifty to two hundred feet, inclining northeast 10° to 15°; then an interval of a quarter of a mile, which is occupied by variegated clays, with thin layers of soft sandstone. The whole weathers smoothly and is covered with grass. The next ridge is composed of sandstones, pudding-stones, and conglomerates, rising two hundred to two hundred and fifty feet, inclining 10°. The rocks of this ridge have a reddish tinge and remind one of the conglomerates and sandstones of Echo Cañon.

I find it difficult to account for this tremendous development of quartz with gneiss at the eastern end of the Uinta range. The white quartz beds rise abruptly from beneath the red quartzites, occupying a belt five to nine miles in width, and end as abruptly as they commence. I do not know why they should appear at this locality, when further to the west, at the sources of Black's Fork and Bear River, where the rocks rise to an elevation of over 13,000 feet, no trace of them can be seen. Here the red quartzites and the white quartz beds seem to conform, and on the side fronting Brown's Hole the red quartzites present an enormous thickness. On the summit, toward the outer portion of the white quartz belt, there is only a thin remnant remaining. I could not spare the time to study this portion of the range to my satisfaction, but I am inclined to believe that the immense thickness of quartz was thrust up beneath the red quartzites, carrying the latter so high up that they have been swept away by erosion, except the remnant now remaining.

When we passed over the high ridges on our way to Brown's Hole from Henry's Fork we spoke of a high carboniferous limestone ridge on our left or north side. This extends down the river about five miles and juts up against the quartz ridges and disappears. Below this point there is a space of ten miles or more, where all the formations from the cretaceous to the quartzites, inclusive, seem to have been swept away, and as I have previously stated, the cretaceous clays jut up against the sides of the quartz ridges. The geology of this portion of the Uinta range is very complicated and interesting. To have solved the problem to my entire satisfaction would have required a week or two. To understand the whole structure clearly my examinations should have been extended to Bear River and beyond. I have no doubt that after a little interval these quartz ridges connect with the range of mountains south of the Vermillion Creek.

Green River cuts a channel through the eastern end of the Uinta Mountains diagonally. At the upper end the unchanged rocks only lie on the east side of the river, but before reaching Brown's Hole the river cuts through the great thickness of the red quartzites. We thus have here a most interesting semi-quaquaversal, on a large scale, including within it several smaller ones. South of Henry's Fork, and east of Green River, the principal ridges incline to the northwest. They gradually flex around until at Red Creek they dip to the northeast, thus forming nearly a semicircle from west to east by way of north.

Red Creek passes directly through one small semicircle or semi-quaquaversal, the general dip of which is northeast. Each end bends around so as to jut up against the mountains. At the head of the little branch that flows into Red Creek from the north, between the massive ridges of brown tertiary sandstones and the quartz beds, there is a singular feature, which is an apparent non-conformity—for about four miles up the stream, on the left or east side rising at first one hundred and fifty to two hundred feet, and dipping about 10°. As we approach the head of the bench, this ridge slopes down to the valley and apparently passes beneath the softer beds. At this point commences a series of nearly vertical ridges trending to northwest, and growing thicker and thicker until the lower and middle tertiary ridges are included. The distance between the northern end of the ridge, dipping 10°, and the south end of the same ridge, holding a vertical position, and in some cases passing a vertical 10°, is not more than one hundred yards. There is a similar illustration about five miles up the valley of Henry's Fork. On the north side of the Creek the beds dip at a small angle, while on the opposite side they extend up to the westward, inclining at an angle of 60° to 75°.

On the high ridges at the head of the little branch of Red Creek, I found in a rusty sandstone impressions of deciduous leaves, among them a *Platanus;* also a species of poplar, and a Sabal, the same species probably which occurs in the coal-bearing beds near Point of Rocks, on the Union Pacific Railroad. There are also some thin seams of coal here, but the indications of coal are nowhere very marked in the vicinity of this portion of Green River. On the east side of Green River, opposite the mouth of Henry's Fork, there is another fine example of a series of semicircular ridges on a small scale. At this point all the formations from the quartzite nucleus of the Uinta range, far to the northward until the middle tertiary beds become horizontal, follow each other in perfect order of sequence. The angle of inclination varies much, but the change is so gradual, and the ridges follow each other with such regularity, that no want of conformity can be detected. The geological structure of this portion of the Green River country is very complicated, but interesting. I have already shown that members of all the formations of the geological scale, known to exist in this portion of the West, are largely developed here; that the erosion has been so slight, comparatively, that they are all turned up to the scrutiny of the geologist.

Before leaving this portion of the country I will say a word in regard to its supposed mineral resources. So far as the physical evidence is concerned the practical miner would pronounce the quartz range of Green River one of the richest localities for gold and silver in the West. About a year ago a large number of men prospected it with the usual enthusiasm, but most of them returned disappointed. At the present time a few miners are exploring the range near Vermillion Creek with some success. The following lodes have been located near Vermillion Creek, in what is called the Brown's Hole district:

1. "Lone Star Lode," twenty-five feet wide. Both walls composed of gneiss. Dip 75°, strike north of west, or nearly northwest and southeast. 2. "Bull of the Woods." South wall well defined. Crevice twelve inches wide on the surface, increasing to three feet as the shaft was sunk twenty feet. 3. "Miner's Glory." Neither wall known. Crevice six feet wide at present. 4. "Green Oil Lode." South wall well defined, six feet wide. An analysis of some of the ore from one of the lodes showed the existence of $12 in silver, and $1 50 in gold. That there is enough of the precious metals here to attract the miners for a time, there seems to be no doubt; but my impression is that they will never prove rich enough to reward the expenditure of much labor or capital. Still, only the most superficial examinations have been made up to this time, and the future may show richer developments.

Although the tertiary beds are so well exposed in the vicinity of this portion of Green River, there are very few indications of coal, and these are quite obscure. On a branch of Red Creek are two or three seams of dark clay or carbonaceous shale, which might lead to thin beds of coal, but no marked signs, as are seen along the railroad at Rock Springs, Point of Rocks, &c.

October 11.—We left Henry's Fork for Green River Station, on the Union Pacific Railroad. It had been our intention to cross the country on the east side of Green River to the head of Bitter Creek, but the reports of its extreme ruggedness and the lateness of the season prevented us. We concluded that it would be safer to take our teams over a well-traveled road, on the west side of Green River, which led us to the old stage road near Bryan. As we ascend the hills on the west side of Green River from our camp on Henry's Fork, we pass over the outcropping edges of the tertiary beds, forming a splendid section. The lower hills, which rise in terraces and are underlaid with dark brown clays, I believe to be of upper cretaceous age, though I was unable to find a single fossil in them. This opinion is strengthened by the fact that the first upheaved ridges south of Henry's Fork, which must lie geologically directly under these clays, is plainly lower cretaceous. The first hard bed above the cretaceous clays is a rusty yellow sandstone, then comes a series of alternate beds of drab-brown indurated clay, with thin beds of rusty-brown sandstone; some of the rocks slightly calcareous, inclining at an angle of 60° to 75°, and extending across Green River, with a trend east and west. The sandstones vary in thickness from a few inches to several feet, while the clays vary from a few feet to fifty or one hundred feet in thickness. Then come beds of massive sandstones, reddish-gray, with seams of clay between, one hundred and fifty feet thick; then a light-gray, fine-grained, massive sandstone, weathering by exfoliation—fifty feet; then a harder bed of iron-rust-yellow sandstone, projecting above the other rocks, with a tendency to a concretionary structure, and weathering into grotesque forms—with cavities one hundred feet; then a series of thin beds of yellow drab sandstones, with a reddish layer, with partings of clay. These sandstones, as they stretch across the country, present a marked banded appearance. All these beds incline at various angles at different localities. Here they are nearly vertical, but on the east side of Green River the same beds incline at an angle of 15° to 20°. The series of beds above described are plainly lower tertiary, and are separated from a succeeding series by a valley about one-fourth of a mile in width. On the border of this valley, some of the upper beds of this first series incline past a perpendicular 45°. This excessive dip is not uncommon among all the stratified rocks in the vicinity of the mountain ranges, but I suspect it is confined to the surface, and that some distance in the earth the beds have their normal dip. I was unable to find any fossils in this series of beds, nor any indications of coal. Crossing the valley we come to a second series of variegated sandstones, mostly yellow and rusty brown, standing nearly vertical with the same strike as the first series, and about five miles up Henry's Fork. This interesting valley is filled up with beds which show a perfect conformity. The first bed is a yellow-brown, rather fine-grained sandstone, dipping 75°, a little west of north. Then comes a series of yellow and light-gray arenaceous or marly clays, with beds of yellow-brown and light-gray sandstones projecting somewhat above the surface. Alternating with these layers of sandstone, are quite thick beds of pudding-stone and conglomerate, composed of rounded pebbles of all the older formations. But what surprised me most were the large masses of purplish sandstones and quartzites, and the carboniferous limestones, sometimes forming the greater portion of thick beds of the conglomerate, four feet in diameter, somewhat worn, evidently derived from the nucleus of the Uinta Mountains. These conglomerate beds are intercalated among the sandstones through three hundred or four hundred feet in thickness, and are probably of upper eocene age. Above them are at least five hundred feet of sandstones, which have a diminished dip 20° to 30°, and then pass up into the calcareous layers of the middle tertiary or Green River group. We thus see that the aqueous forces that deposited the sediments of the upper eocene beds were brought to bear on the summits of the Uintas, and we can form some conception of the vast period of time they have been subjected to erosion. Since that time all the middle and tertiary beds, comprising many thousands of feet of strata, have been deposited in this region. At the base of this second series of sandstones is a thin bed of carbonaceous clay, and above and below it are layers of sandstone a foot thick or more, composed almost wholly of *Melanias*, *Paludinas*, and *Unios*, with some reptilian remains. We thus reach a point downward where we can decide that the waters in which these sediments were deposited were purely fresh-water. Green River flows between high vertical walls of these beds, and the opportunity to follow them, step by step in their order of sequence, is excellent.

We pass gradually up to the Green River beds, where lime forms a large constituent. About two miles north of Henry's Fork the strata become nearly horizontal, and continue so far up Green River toward its source.

As we pass over the uplands on our way northward toward the railroad, we have on our left hand or west side a long, high, broken ridge of the brown indurated clays of the Bridger group, three hundred to four hundred feet high, which seems at the present time to form the eastern limit of this group. That it continued eastward at one time, perhaps far across Green River, I have no doubt, because remnants of it are seen high up near the banks of Green River; and on the Big and Little Sandy Creeks, which rise in the Wind River Mountains, are quite extensive developments of this group, with an abundance of the peculiar vertebrate fossils. It is quite possible, also, that the long, high ridges, which so closely resemble them, south of the old stage-road near La Clede and Dug

Spring Station, which extend off toward Muddy and Bear Rivers, of which Hay Stack Butte forms a part, are portions of the same group; if so it is a matter of great interest to trace the results of the denuding forces, which have operated so energetically all over this country in geological times. It forms one of the greatest charms of the study of the geology of the West to trace the connections of different groups of beds across intervening spaces, where they have been removed by erosion alone or by the upheaval of mountain ranges, to take up the broken links in the history and unite them together. As I have before stated, we gradually pass up through the second series of sandstones to a third series of laminated marls, with thin layers of chalky limestone. Near the middle of these marls are some layers of chalcedony, composed mostly of *Goniobasis*, masses of which are strewed over the surface in great quantities. Fragments a foot square are covered on both sides with beautiful specimens of *Goniobasis*, while about ten feet below is another layer of limestone filled with *Unios*, with a few *Goniobasis*. Fragments of turtle shells are quite abundant in the marly clays. These laminated marls reach a thickness of two hundred or three hundred feet, and weather into very symmetrical rounded hills or buttes, contrasting quite strongly with the style of form of the Bridger clays, though similar in type. Their shaly character is always noticeable, and their radiating furrows, so characteristic of indurated clays, are wanting.

Before reaching the crossing of Green River, nineteen miles north of our camp near the mouth of Henry's Fork, a thick bed of rusty-yellow sandstone makes its appearance. This sandstone is well shown on the banks of Green River. It caps the high bluffs along the river near the station on the railroad, and assists in giving the peculiar forms to the hills. On Black's Fork the disintegration of this sand bed, as it comes to the surface, has produced large banks of loose sand. The surface of the country along Black's Fork and up to Green River Station is quite sandy. No portion of the country over which we have traveled seems to be so entirely destitute of vegetation as that between Henry's Fork and the railroad, and yet the soil possesses all the elements of extreme fertility. If it could be well irrigated it would produce forty bushels of wheat per acre. The bottoms of the streams produce good grass, and are now occupied by numerous herds of cattle.

CHAPTER VI.

FROM GREEN RIVER STATION, VIA BRIDGER'S PASS, TO CHEYENNE, WYOMING TERRITORY.

From this point to Black Buttes, a distance of seventy miles, we follow the valley of Bitter Creek, along the immediate line of the Union Pacific Railroad. The geological features of this region are of great interest, and, inasmuch as the detailed account of them is included in the chapters on the third belt, along the road from Cheyenne to Salt Lake, I shall pass over this portion with only a few general remarks, sufficient to connect the geological formations of the two points.

The Green River group can be studied to the best advantage along the valley of Green River, where the sides of the bluff banks rise to a perpendicular height of five hundred feet or more. The "cuts" along the railroad, from Rock Springs to Bryan Station, aid us very much in reading the true history of the strata and securing their fossil remains.

Ten miles east of Green River Station, the Green River group disappears abruptly on the south side of Bitter Creek, and the coal formations come up to view. On the north side, the eastern limit of the Green River beds is most sharply marked by a long, high, white bluff, that extends off, far to the northeast, toward the South Pass.

The dip varies from 3° to 5°, and the laminated calcareous shales gradually pass down into yellow, gray, and brown indurated arenaceous clays, sands, and sandstones, until the well-defined coal strata are exposed, without the least appearance of discordancy.

Both the middle and the lower tertiary beds incline to the northwest. At Rock Springs the extensive and valuable mines of the Wyoming Coal Company are located. The lignite coal beds continue for a distance of about six miles east of Rock Springs, with a dip of 10°, where a series of yellow and drab-brown indurated clays rise up from beneath the sandstones, and continue for eight miles, to a point about two miles east of Salt Wells Station. This interval forms a sort of low, valley-like space, which is well marked, on account of the rounded and far less rugged style of weathering which extends off to the northeast of the railroad, on one side, and southwest on the opposite side. East of Salt Wells the coal-bearing beds appear again, with an opposite inclination, about 10° to the southwest, proving this interval to be a true anticlinal valley. Not a fossil was discovered in these clays to fix their age with certainty, but I have no doubt that they belong to the upper cretaceous period, and are an extension, to the north or northeast, of those cretaceous clays already noticed as occurring near the mouth of Henry's Fork, on Green River. I believe it to be the extension northeastward of the axis of elevation of the Uinta Mountains. I think, however, that it dies out, or is concealed by more modern tertiary beds, before reaching the Sweetwater Valley.

Continuing eastward from Salt Wells Station, the gradual inclination of the strata exposes a splendid section of the eocene coal beds. Not less than 1,000 to 1,500 feet of sandstones and clays are passed over before we come to the valuable coal beds near Black Buttes. At this point the old stage road diverges to the south of the railroad, following up the south branch of Bitter Creek.

Soon after leaving Black Buttes we cross the western rim of the series of middle tertiary beds, which I have named the "Washakie group." The transition from the coal beds is through a series of indurated arenaceous clays, with beds of sandstones of all colors and texture, bearing upon their surface the evidence of their more modern date. The inclination is in the same direction and in accordance with the lower tertiaries, but the dip is not more than 3° to 5°.

At Big Pond Station, fourteen miles east of Black Buttes, the deserted buildings of the old stage station are entirely built of rocks composed of fresh-water shells. There are two kinds of rock, viz, a calcareous sandstone, formed of an aggregate of *Unios*, *Viviparas*, *Goniobasis*, &c., but all casts, the sandstone being so porous that the calcareous shell has been entirely dissolved away; still the rock itself effervesces very briskly on the application of hydrochloric acid. Another bed, varying in thickness from six to twelve inches, is a very compact limestone, somewhat siliceous. This is simply an aggregate of *Goniobasis* cemented with a little lime and silica. The texture of the rock is so close that it is difficult to obtain any perfect shells.

Table Rock is a high, flat-topped "butte" north of this point. The underlying yielding clays are protected from erosion by these beds of shell rock. All the rocks used for building purposes along the railroad at Table Rock and Red Desert, and on the old stage road at Big Pond and La Clede, were taken from these shell beds. These layers of rock extend over hundreds of square miles, and all the buildings for large cities might be constructed from the aggregate remains of these little fresh-water animals. Marine limestones of great thickness, composed entirely of organic remains, are not uncommon in various portions of our own county, but I have never known such extensive beds of rock made up entirely of a few species of fresh-water shells. At the present time both fresh-water and land shells are very rare in this country; the physical conditions seem to be very unfavorable, except at the sources of some of the tributaries of the Missouri River that come in from the north, as the James, Vermillion, and Big Sioux Rivers. These streams are filled with *Unios*, *Viviparas*, *Lymneas*, *Planorbis*, *Physas*, &c.; and yet the conditions seem to have been more favorable in years past for this kind of life than at present. In the fine vegetable matter that accumulates along the Missouri River from the annual floods, I have seen bushels of minute *Helices*, *Pupas*, *Succineas*, &c., and yet I have looked in vain for any of these shells alive in the little streams in the vicinity. In the banks of the streams that flow into the Lower Missouri, as Big Sioux, Vermillion, and others, large accumulations of fresh-water and land shells are found buried fifteen to twenty feet beneath the surface; yet it seems to me, that if all that have ever existed in this region were gathered together, they would not cover a large area. In the Missouri River, from the base of the mountains to its entrance into the Mississippi, scarcely a shell can be found, and very few ever are seen in any of the branches that flow in from the south. The inference is, that the impurity of the waters over the greater portion of the West is such at the present time that this class of life cannot exist. How favorable, then, must have been the conditions for the increase of molluscous life in these old tertiary times! Not only were the waters pure, but throughout all the vast thickness of middle and upper tertiary deposits in the beds of clay and sandstones, there is more or less calcareous matter, as is shown by the application of an acid; proving that lime, which is so essential to these animals, must have existed in the waters of that period. About six miles east of Big Pond Station, a well-marked bed of reddish clay is exposed, which can be seen extending across the country, over the sides of the bluff-like hills, for many miles. I call attention to this red band of clay, from the fact that it seems to mark the appearance of the lower portion of the middle tertiary, and increases or diminishes in importance in different localities. On the east side of Green River, opposite the mouth of Henry's Fork, these clays, with a reddish tinge and bands of light brown, reach a thickness of one hundred to one hundred and fifty feet, and weather into quite regular and picturesque forms.

On the west side of the South Pass these light-red clays are well displayed near the base of the middle tertiaries, and in some calcareous layers above them are multitudes of fresh-water shells. This band is also seen at the eastern terminus of the Green River group, near Rock Springs, and near the sources of the Muddy west of Bridger's Pass. It also gives name to the station on the Union Pacific Railroad, "Red Desert," from the fact that the contiguous hills receive their color from it.

Whether these formations are connected geographically or chronologically with the vast series of red beds west of the eastern rim of the Great Salt Lake Basin, a more extended exploration must determine. The shell beds lie above this in all the localities that I have examined except near the South Pass, where a bed of very porous sandstone occurs near the base of the series, made up of casts of *Unios*, *Lym-neas*, &c.

Between La Clede and Barrel Springs the strata are very nearly horizontal. The surface is less rugged; still to the south of the road are high, rather abrupt ridges, and in the distance are quite pointed ridges three hundred feet high, composed of the somber, hard, indurated, rusty arenaceous clays which characterize the Bridger group. Indeed, from its form and style of weathering, and the color of its sediments, it could not be distinguished from the high ridges of Bridger beds west of our road from Henry's Fork to Green River Station. Although I have hitherto regarded the group of beds which I have denominated the "Washakie group," as separated from those of Greeen River and to the westward, yet I am now inclined to believe that the upper series is either an extension eastward of the Bridger group or synchronous with it. Fragments of turtles and other vertebrate remains are not uncommon.

Near Barrel Springs a very good section of the laminated, chalky clays is exposed in the valley of the Muddy; seams of shells as *Unio tellinoides*, *Goniobasis tenera*, *G. nodulifera*, and *G. Carteri*, four inches thick, occur above and below thin layers of rotten vegetable matter. These shells occur through fifty to one hundred feet of these chalky beds. Remains of turtles, also vertebræ of fishes and reptiles, are found; a few obscure plants, like blades of grass, stems of rushes, &c., occur in the clays; still higher on the tops of the hills that border the stream, are some thin, chalky clays, crowded full of plants, as ferns, rushes, grasses, palms, &c., finely preserved. Fragments of palm-wood and those of deciduous trees are scattered over the surface in great profusion. I think I have never seen vegetable remains more abundant or more easily obtained in any portion of the West than at this locality. There was about two feet of strata composed of them, and they split into very thin regular layers, as light as dry vegetable matter could be, and each side of the thin layers was covered with beautiful impressions of leaves in a remarkably fine state of preservation. Upon these weathered hills were literally bushels of very pretty *Goniobasis* and *Unios*, which one could gather to his entire satisfaction. I regretted very much that my party could not remain a day in this interesting region; but the almost entire absence of grass and the alkaline water compelled us to hasten on with our half-starved animals.

From Barrel Springs we descend geologically, the dip of the rocks being reversed, and the same beds rise to view that we saw in traveling eastward from Black Buttes. As we descend into the valley toward Duck Lake, the pinkish bed makes its appearance, and on the left of the road is an isolated mass of sandstone, about twenty feet cube, which forms a sort of landmark. Although this red layer is a conspicuous feature in this region for miles along the valley of the Muddy, yet this isolated mass is the only example of hardened rock connected with the red band in this region. There must have been some local cause originally for the greater tenacity of the cementing material in this restricted locality.

The water divide of this region is undoubtedly Bridger's Pass, but the geological divide I regard as located between La Clede and Dug Spring Station. Here the strata are nearly horizontal, or from what might be called a synclinal. Along the Union Pacific Railroad at Dodge's Summit, the water and geological divide are identical. The strata west of this divide incline slightly northeast, and on the east side southwest. As I have already stated in a preceding chapter in describing the tertiary formation from Bridger to Green River, they may be separated provisionally into four series.

First series.—The coal strata, lower eocene, characterized by numerous impressions of deciduous leaves, marine and fresh-water mollusca.

Second series.—Arenaceous, upper eocene, characterized by a profusion of fresh-water shells, as *Unios*, *Goniobasis*, *Viviparas*, *Lymneas*, &c.; a portion of these being casts.

Third series.—Calcareous, lower miocene, containing the greatest abundance of fresh-water shells, plants, fishes, &c.

Fourth series.—Arenaceous clays—upper miocene—turtle shells; no other fossils observed. The third series of beds contains the plants and shells that were found in such profusion near Barrel Springs on the Muddy.

Continuing our way eastward, we descend across valleys and over ridges, with the outcropping edges of bed after bed of sandstone and clay rising to view, until we come to the coal strata near Washakie Station, on a branch of the Muddy flowing down from Bridger's Pass. The dip is hardly perceptible at first, but gradually it reaches 5°.

Through the eocene and cretaceous beds, even to the granites, the inclination may increase, or in some cases diminish. In some instances the eocene beds are vertical, while the carboniferous strata beneath, incline at a small angle. There is no apparent discordancy between the four series of tertiary beds noted above. Along Green River, at Rock Springs, Black Buttes, and west of Bridger's Pass, no want of conformability could be ascertained. Yet there must be some discordance between the upper tertiaries and the older beds, from the fact that the Bridger group and the Monument Creek group, as well as the upper portions of the White River group, jut up against the older beds in many places in a horizontal position or incline at an angle of 3° to 5°. This is the case along the eastern flanks of the Laramie range, and on the sides of other mountains in numerous localities. Near Fort Laramie the White River beds, which may possibly be of pliocene age, have been deposited high up, in the ravines, on granites, or on the upturned edges of carboniferous limestones, and yet in the plains these same beds seem to conform perfectly to the old tertiaries, and the latter conform perfectly to the cretaceous, Jurassic, triassic, carboniferous, and Silurian beds.

After passing Duck Lake Station we ascend barometrically, although we descend geologically, lower and lower beds rising to view continually, and just before reaching Washakie Station the lower tertiaries or lignite beds make their appearance, with a dip of about 10°. I think the fresh-water shells that occur here in sandstones so abundantly belong to the third series of upper eocene beds that gradually pass down into the coal strata. About a mile west of Washakie the beds of coal are exposed, and the examples of the baking, and even the melting, of the adjacent rocks by the spontaneous ignition of the coal-beds, are very common. The ridges are covered with these red or burnt places, which look like piles of cinders. In some beds of gray calcareous sandstone over the coal I collected great quantities of large deciduous leaves of trees belonging to the genera *Platanus*, *Populus*, *Tilia*, &c., evidently the same species as those found in other localities connected with the coal formations. The coal strata reach a great thickness around Bridger's Pass, and are composed of alternate beds of sandstone with layers and concretions of calcareous sandstone. In the upper portions the clays predominate and contain the coal seams, which vary in thickness from a few inches to ten or twelve feet. As we descend toward the cretaceous beds, the sandstones begin to predominate, until they rise on our left hand, as we ascend the "pass," in lofty, nearly vertical walls. The trend of the ridges is about northeast and southwest. The branch of the Muddy, which rises in the "pass," seems to form the line of separation between the coal-beds and those of well-known cretaceous age. A bed of massive sandstone forms a wall on the north side nearly to the head of the Muddy, where the softer clays of the cretaceous seem to rise from beneath it. On the south side of the road is a high, rugged group of hills, which weather into rounded forms, which are plainly upper cretaceous. Since leaving Washakie there has been a decided improvement in the vegetation; grass grows quite abundantly on the hills and in the valleys, and the shrubs and trees have the healthy growth peculiar to the foot-hills of the mountains.

Between Bridger's Pass and Pine Grove the wall on the north side continues much the same, but the cretaceous clays seem to underlie the sandstone; but on the south side the cretaceous beds rise up abruptly to the height of about eight hundred feet above the road; and on the summit is a broad plateau, covered with a deposit of drift material, and well grassed over. Here and there we see beautiful groves of aspen and pine. The belt of cretaceous beds is very wide. In the vicinity of Bridger's Pass there is an enormous thickness of the coal strata, which I have estimated at three thousand to five thousand feet. The inclination is 10° to 15°. The cretaceous clays are also very largely developed fifteen hundred to two thousand feet. Near Aspen Grove I found *Baculites ovatus* and some undetermined marine shells. At Pine Grove the wall on the north side extends across the country, towards Rawlings' Springs, in one of the most handsome and symmetrical anticlinals I have observed in the West. The valley is about four miles wide between the outcropping walls, and forms a sort of rolling prairie, which shows the style of surface weathering when underlaid by the soft, yielding, cretaceous clays. The trend of the valley is northeast and southwest, and forms an extension of the axis of elevation of some range of mountains near Bear River.

About northeast of Pine Grove there is a small lake in this valley, half a mile long and nearly the same width, the shores of which are covered with an alkaline efflorescence. This anticlinal valley is of the same character as the one that forms the extension of the axis of the Uinta range at Salt Wells, on the Union Pacific Railroad. Here we see the same smooth, rounded appearance to the surface from Rock Springs to a point about two miles east of Salt Wells, where the outcropping edges of the coal-bearing rock appear. Passing up the South Fork of Bitter Creek, we have the more modern tertiary beds inclining at a small angle. Near La Clede Station is a high ridge, extending across the country like a low range of mountains, composed of the somber indurated, sandy clays of the upper miocene, of which Haystack Butte forms a part. Continuing our way eastward, we descend again across the edges of the same beds we saw on Bitter Creek, and gradually passing through a tremendous thickness of eocene coal strata, reach the soft clays of the cretaceous group. The exact line of separation between the true cretaceous and tertiary beds in this region I cannot positively determine. We know that fossils, brackish and sometimes purely fresh-water, characterize the upper eocene above the thickest coal beds; that at Hallville, in the dark clays or slates, above one of the most valuable coal beds, there is a profusion of *Cyrenas* and other brackish-water fossils; that, as we descend in the coal strata, beds of several species of *Ostrea* are found; showing clearly that the great lake at this time had access to the salt sea. I am not able to draw the exact line of separation between the tertiary and the cretaceous beds in this region, and I am inclined to believe that there is a considerable thickness of what may properly be called transition beds, or beds of passage, which will probably remain a long time in doubt.

From Pine Grove we continue on our course to the eastward, with the high wall of sandstone on the left and the plateau on the right. Nearly opposite Pine Grove Station the anticlinal that extends off toward Rawlings' Springs forms a notch or triangular area, in which the cretaceous clays are worn into three singular, terrace-like ridges on the west side, with a strike southwest and northeast, and on the east side, northwest and southeast.

The valley of Sage Creek is three to six miles wide. On the North Platte there is a fine exhibition of the sandstones or transition beds. Near the crossing of the old stage road there are vertical bluffs eighty to one hundred feet, composed of grayish-brown sandstone, which exhibits, in the most remarkable degree, the various signs of shallow-water depositions, as ripple, rain, and mud-markings, with what appear to be trails of worms, &c. Broad, flat masses of sandstone lie at the base of the bluff fifteen or twenty feet square, with the surface covered with these peculiar markings; oblique layers are not uncommon. The indurated clays of well-known cretaceous origin are well shown here, extending up the North Platte for fifteen or twenty miles to the southward, while, to the north, ridge after ridge extends as far as the eye can reach. There are alternate beds of sandstone and a steel-brown indurated clay. In the second bed of sandstone from the bottom are great quantities of a species of *Ostrea.* As we pass up in the series we find irregular concretionary beds of rusty calcareous sandstone, with some fossils, especially *Ostrea*, and a few other marine or brackish-water species. Everywhere in the West the oldest or lowest coal beds contain more or less marine fossils, most of which belong to the genus *Ostrea.* They are found, in about the same position, from latitude 49° to New Mexico. Where the beds are studied with some care, in a favorable locality, we soon find that the marine evidences disappear, and the organic remains are purely fresh-water or terrestrial.

On the morning of October 23 we left our camp on the North Platte and wound across the plains a little north of east to Pass Creek. To the west and southwest, as far as the eye can reach, there is a rolling or partial plain country, occupied by cretaceous beds. From the high ridges on the east side of Platte we can cast a glance back along the route we have traveled, over one of the most comprehensive views I have observed in the West. On the north side is the continuous wall of sandstone, from Bridger's Pass to Medicine Bow, extending up the Platte River, and retreating with a gentle dip northeast, like descending steps, or rather like chopped waves. The clays underneath the sandstone ridges are undoubtedly of cretaceous age; but I have been inclined to regard the group of alternate beds of sandstones and clays, which are so conspicuous from Bridger's Pass to Medicine Bow River, and give the characteristic surface features to a very large area, as transition beds or beds of passage from the true cretaceous era to the tertiary. It is true that we find here and there a specimen of *Inoceramus* or *Baculite* and numerous beds of several species of *Ostrea;* yet the time which must have been required to bring about the changes in the sediments and animal life, from a purely marine condition to that of purely fresh-water, must have been immense. That a few of the more hardy marine forms of mollusca should have lingered on up into the period of the coal, would not and need not surprise geologists. So consecutive do the different beds appear to be, that I am of the opinion that, however minutely they may be studied hereafter, the line of separation between the true cretaceous and tertiary beds will be arbitrary. There are many localites in the West where the line of demarkation is so well defined by the absence of some beds that it cannot be mistaken, but I will discuss this question more fully hereafter.

Through the broad valley winds the North Platte River with remarkably picturesque beauty, with grassy bottoms, and here and there a group of large bitter cottonwoods. To the south and southeast is a snow-covered range of mountains, walling in the North Park, and forming a portion of the water-shed of the continent. Far up the Platte Valley, for thirty or forty miles, the surface is slightly broken, with the appearance that the soft cretaceous clays would give it.

There is a broad belt of the cretaceous beds extending along the base of the mountains and running across the course of the Platte. To the eastward rise the four rounded mountains of the Medicine Bow range, of which Elk Mountain forms a part. To the north and west the ridges of transition sandstone pass into the true tertiary toward Fort Steele on the Union Pacific Railroad.

The bottoms of the North Platte are quite fertile, and produce excellent grass. The timber is not abundant, but taken in the aggregate there is enough to supply the sparse population that will be likely to settle in this region. The mountains would furnish a most abundant supply.

The sandstones as seen along the Platte are somewhat variable in color and texture. The three lowest and most massive beds, fifty to eighty feet in thickness, are drab brown; the fourth one is yellowish gray, very friable, separated into thin layers, and weathered into somewhat fantastic forms, one of which resembles a human face. This bed of sandstone is full of large, rusty-brown, concretionary masses, which are also divided into thin layers, but are calcareous, really arenaceous limestones. In looking at the surface features of this portion of the country, these four beds of sandstone mentioned above stand out in relief, and give force to the scenery. Between them are some thin layers of sandstone and arenaceous limestone, with seams of dark-brown siliceous clay, more or less slaty. The dip of these beds is persistently northeast.

Leaving the North Platte we traveled in a northeast direction over uplifted ridges for a time. Soon they are so worn down that they are only faintly shown above the surface, and for about twelve miles before reaching Pass Creek our road was over a level plain covered with a thick deposit of drift. The evidences of erosion are very conspicuous between the North Platte and Pass Creek. The broad, level plain was once covered with ridges of cretaceous beds inclining at a large angle. On the east side of the plain the ridges dip west and northwest from the mountains. On the southwest side of Elk Mountain are very high ridges of sedimentary rocks, but they are only a few miles in extent. The main ridge, which lies next to the granite, is composed of carboniferous limestone. The valley near it, is formed by the scooping out of the soft, red, arenaceous clays of the triassic; then comes Jurassic, cretaceous, and lastly the tertiary beds, gently inclining toward the plains.

These formations are more or less conspicuously shown, depending upon the texture of the materials. The granite mountains rise up about two thousand feet above the base; the ridge of carboniferous limestone is five hundred to eight hundred feet; the third ridge is cretaceous, one hundred to one hundred and fifty feet, while the drab sandstones of the transition group pass off northward in a series of low ridges.

Leaving Pass Creek, we enter Rattle Snake Pass, with the drab sandstones, underlaid by well known upper cretaceous clays, outcropping on the left hand, and the rather curious, mound-like ridges of the dark plastic clays of the lower cretaceous, on the right. Along the flanks of the mountains it is quite seldom that all the formations are clearly shown. Sometimes portions have been removed by erosion or concealed by drift deposits; or all the beds are so crushed together that only two or three of them are exposed to the eye. At this locality for a short distance, perhaps one or two miles, the lower cretaceous clays are remarkably well shown, lying on the sides of the mountains; while the Jurassic, red-beds, and carboniferous are scarcely seen or are concealed entirely. We know that they must exist here in their full development, for just west of Rattlesnake Creek all these formations are very clearly shown in lofty, well-defined ridges, inclining at an angle of 20° to 40°. These facts show the importance of careful detailed study of the geology of all the mountain districts, and the necessity also for the construction of a suitable topographical map on a sufficiently large scale to show these changes clearly.

Near Fort Halleck the carboniferous limestones rise high up on the sides of the mountains, resting upon the granite. All the more recent beds are worn away or so concealed as not to be visible. East of Fort Halleck the ridges of sandstone bend off to the northwest, while to the east and southeast the sedimentary rocks jut up against the sides of the foot-hills of the mountains.

From Elk Mountain to Little Laramie River there are no remarkable exhibitions of the uplifted sedimentary rocks. For the most part the foot-hills near the base of the mountains are quite smoothly rounded off, and covered with grass; and only here and there are any of the beds exposed. High up in the mountains, toward the sources of the Big and Little Laramie rivers, are some fine exposures of the entire series of sedimentary beds; but these will be described more fully in a subsequent portion of this report.

Along the flanks of Elk Mountain there is exposed, in one or two localities, a vertical ridge of gray sandstone and quartzite, which I have regarded as No. 1, or lower cretaceous. The rock does not differ in texture from the same formations as seen along the eastern slope of the Laramie range from Red Buttes to Cache à la Poudre and southward; but in this instance it forms, for a short distance, a high vertical wall, pressing up close to the granite nucleus, while the carboniferous limestones are carried up on the tops of the granite to the summit of the mountain.

Our camp on the Medicine Bow Creek was a pleasant one, with an abundance of timber, and the greatest supply of grass for our animals. The bottoms are wide and of inexhaustible fertility. The valleys of all the little branches furnish the most extensive and valuable pastoral districts for stock. Beaver dams occur everywhere, and sometimes flood a space half a mile in width. In the branches of the Medicine Bow the plastic clays of the lower cretaceous prevail, in a horizontal position. All the formations seem to jut up against the mountain sides with very little inclination. The river emerges from a sort of jog in the range, ten miles or more south of Elk Mountain, and the cretaceous beds, nearly horizontal, extend down into the plains in long, grassy, bench-like ridges. On the Wagon Hound Creek are some beds of sandstone in a nearly vertical position, or inclining at a high angle from the mountains, which are intercalated with beds of clay and coal seams, evidently the beds of passage to the tertiary.

After passing the Medicine Bow Creek eastward, the country assumes a more cheerful aspect; the water is as pure as crystal, and grass covers the surface very thickly. Dense groves of aspen are abundant among the foot-hills, and the little streams are all fringed with timber. From the summit of a high hill on the west side of Rock Creek we have the finest view of the Laramie Plains I have ever seen. We reached Rock Creek on one of those clear days after a rain-storm, when the sun shines out with that wonderful brightness which is peculiar to this country. The entire area of the Laramie Plains was spread out before us like a panorama. The Laramie range forms a perfect wall on the east and north side, and marks the horizon from the east, around to northwest, and apparently dies out. To the north, Laramie Peak is as plainly visible as it is from Fort Laramie on the opposite side of the range, and rises high above any other portion. The entire surface of the plains east of the Medicine Bow, encircled by the main Rocky Mountains on the south, and the Laramie range on the east and north, has been smoothed off by denudation and grassed over, so that it forms one vast pasture-ground about sixty miles in extent from east to west, and nearly the same distance from north to south. From the mountains on the south side descend, parallel with the valleys of the streams, beautiful benches, with smooth, table-like summits; while forming a portion of the foot-hills of the mountains are numerous rounded hills, grassed over, and paved on the tops and south side with the different kinds of rocks which constitute the nucleus of the mountain range, as garnetiferous gneiss, quartzites of all colors, red and gray granites, with quartz, trap rocks of various textures, fibrous gneiss, &c. These rocks are quite well worn, and they seem to lie on the summits of the hills as they were dropped by an iceberg, and present the appearance of leaning to the northward as if on the move. The shape of the hill and the position of the stray masses impresses one with the thought that they were only delayed for a time on their way from the mountains to the plains. These examples of local drift or erratic blocks are very common and well defined in the Laramie Plains. Indeed, I have never seen any evidences in the Rocky Mountain region of any foreign drift. All the superficial deposits belonging to the quarternary period, seem to me to be local in their origin.

Rock Creek Valley is very beautiful and picturesque. The stream emerges from a very narrow gorge in the mountains, which is covered with a dense growth of pines. As we look down the stream from the gorge the valley seems to expand to two or three miles in width, and there are three belts of trees winding through it as if there were as many separate streams. The other portions of the valley are like a meadow. About half a mile, along the old stage road, on Rock Creek, the metamorphic rocks are well shown, holding a nearly vertical position. There are gray and reddish feldspar beds, inclining 60°. There are also beds of what appears to be ancient trap. These ridges form steps which lead up to the Snowy range. No sedimentary rocks older than the cretaceous are seen in the valley of Rock Creek. The valley is literally covered with water-worn boulders of all kinds, mostly metamorphic, and hence its name. These boulders diminish in size as we descend the creek until they nearly or quite disappear. All the hills on either side show accumulations of these worn rocks on the side facing the mountains. On the east side of Rock Creek the yellow sandstone which underlies the long bench is undoubtedly cretaceous No. 5, and contains a few fossils, among which are the usual *Inoceramus* and *Baculites ovatus*.

On the east side of Cooper's Creek there is a long, high ridge, with its abrupt side toward the mountains, and covered thickly with the rounded boulders—a marked illustration of the direction from which the boulders were derived. The valley of Cooper's Creek is a broad, meadow-like expansion, and produces a thick growth of grass, which supplies an abundant provision for stock in the winter. All these streams emerge from the mountains through narrow cañons. From Elk Mountain to Big Laramie I doubt whether any rocks older than the cretaceous are exposed on the flanks of the mountains, and these in many places are obscured by heavy deposits of drift.

The valley of the Little Laramie is now mostly occupied by ranches. Thousands of cattle wander over its broad meadows and on the upland plains, and hundreds of tons of hay are prepared every year. It is probable that this region is destined to become celebrated as one of the finest pastoral districts in America.

Leaving Big Laramie we ascended the western slope of the Laramie range by way of Cheyenne Pass, across the cretaceous, Jurassic, and triassic or red beds. The latter gives a bright brick-red appearance to a wide belt along the east side of the road for 30 to 40 miles. A bed of bluish limestone covers the western slope of the Laramie range with remarkable uniformity, like the roof of a house, inclining 10° to 15°. Underneath this, toward the summit, a bed of yellowish-white limestone appears, with well-marked carboniferous fossils. Toward the summit of the range we pass over a depression or valley of considerable depth, which seems here to separate the changed from the unchanged rocks. We then come to reddish micaceous feldspathic granites. Indeed, all varieties and textures of granitic rocks occur on the summit of this range. We continue to travel over ridge after ridge of metamorphic rocks—some very fine in texture, others quite coarse—until we come to the smooth, plain-like area which forms the central portion. This grassy belt constitutes the real crest or divide, and after passing this we travel over ridge after ridge of metamorphic rocks similar to those on the west side, but with a reversed dip, showing a distinct anticlinal; and at the east end of the pass, at the sources of Lodge Pole Creek, the metamorphic rocks rise up from beneath the red sands and limestones in perfect conformity, so far as they are visible to the eye. On the east slope are broken ridges, which show the carboniferous limestones inclining 3° to 10°. Curiously rounded ravines, carved out of the ridges by water, separate them into picturesque fragments. The road through Cheyenne Pass is excellent, and is paved with crystals of feld spar. The soil is fertile and the grass is good.

South of Laramie Peak there is a great scarcity of timber on this range, so that it does not deserve the name of "Black Hills," which is often applied to it.

Just south of Crow Creek there is an illustration of the granite rocks carrying up the carboniferous limestones on their summits in a nearly horizontal position. The tertiary beds jut up against the base of the range, entirely concealing all traces of older rocks, so that larger areas of older formations are broken off and lifted up far above the plains on the summits of the mountains. This is not an uncommon occurrence along the flanks of all the mountain ranges. It only shows how interesting and complicated are the details of the study of these ranges, however simple their structure may seem to be in the aggregate.

Leaving Cheyenne Pass, we cross over a remarkable parallel valley, or one which has been scooped out near the base of the mountains and extends along parallel with it. It extends from the ridge south of the drainage of Crow Creek to the Chugwater. The modern tertiary beds extend down to Cheyenne, a distance of fifteen miles.

We have now (November 1,) reached our point of departure on the 6th of August last. Two belts of country have been explored: 1. North of the railroad by way of North Platte, Red Buttes, Sweetwater, South Pass, to Fort Bridger. 2. South of the railroad, from Fort Bridger via Henry's Fork, Green River, Bitter Creek, Bridger's Pass, Medicine Bow Mountains, Cheyenne Pass, to Cheyenne again.

We shall occupy ourselves next with a description of the third or middle belt connecting the two already described, extending from Cheyenne to Salt Lake Valley along the line of the Union Pacific Railroad.

We shall also gather up some of the fragments from point to point which may have been omitted, or not fully explained, in the preceding portions of this report.

PART II.

GEOLOGY OF THE MISSOURI VALLEY.

CHAPTER VII.

GENERAL VIEW OF THE GEOLOGY OF THE MISSOURI VALLEY.

In order that our description of the geology of that belt of country bordering the line of the Union Pacific Railroad may be more clearly understood, we may in this chapter take a somewhat hasty glance at the principal geological features of the vast area drained by the Missouri River and its tributaries. The geologist is dependent for his knowledge of the earth's crust, either on natural sections formed by the channels of rivers, or the upheavals of mountain chains, or on the artificial cuts along railways, or artesian borings. The great Missouri cuts a section from its source in the mountains to the Mississippi, a distance of nearly 3,000 miles, affording an excellent opportunity for studying the various geological formations which occur in the Northwest. The branches also, which make their way from distant points on either side of the Missouri, cut the country up in every direction, so that it is hardly possible to fail in obtaining at least, an approximately correct interpretation of the records. The cuts along the line of the railroad are, as it were, slices in the earth's crust which often reveal the nature of the underlying formations with wonderful clearness, throwing a flood of light upon obscure points. Many of the observations also, which were made for practical purposes by the engineers, as well as the exploration for useful minerals in the vicinity of the road, may be brought into the service of science. Thus the elevations which have been taken with great care across the continent from Omaha to San Francisco are very useful. Along a well-known line of travel, the attention of the student of geology will most likely be attracted toward the principal geological features, and on this account I hope to make the succeeding chapters a sort of guide in this respect. My observations, which have extended over a period of about three years, may be regarded as correct in the main, though every year new facts will be added.

Before starting on our westward tour let us study for a little time the wonderful section which is revealed to us along the channel of the Missouri River. It has long been known that the northeastern portion of Nebraska is underlaid by rocks of the upper coal measures. These rocks are well shown from the south line of the State to the mouth of the Platte River, where they are partially concealed by a great thickness of recent deposits. They gradually disappear beneath the water-level near De Soto, about thirty miles aboveOmaha. If we ascend the Platte River for a short distance we shall find the carboniferous limestones finely exposed, and the opportunities for their study are very much aided by the numerous quarries which have been opened. They, in their turn, pass beneath the water-level of the river, near the mouth of the Elkhorn, and are not again visible until they are exposed along flanks of the mountain ranges. So far as Nebraska is concerned, the carboniferous rocks seem to be directly overlaid by the rusty sandstones of the lower cretaceous, No. 1. In the valley of the Big and Little Blue

Rivers some yellow and buff magnesian limestones occur, which are suggestive of permian relations, but it is quite doubtful whether rocks of that age extend up into Nebraska, although they occur in Kansas. On my geological map I have usually colored a small strip of permian extending up into Southern Nebraska, but our present knowledge would indicate that it might be omitted. Although some of the fossils seem to possess permian affinities, they all extend down into the coal measures, and therefore are not peculiarly characteristic. As we have before remarked, the carboniferous rocks along the Missouri River are immediately overlapped by formations of cretaceous age. These rocks as revealed along the Missouri, have been separated into five well-marked divisions, which have been designated by numbers 1, 2, 3, 4, and 5, and by groups, as Dakota Group, Fort Pierre Group, and Fox Hills Group. Inasmuch as we shall have occasion to refer to these groups in describing rocks in the cretaceous epoch in other portions of the West, we will introduce here a general section of the cretaceous rocks along the Missouri River, as prepared by Mr. Meek and the writer several years since, and published in previous reports. There are so many students of western geology scattered over the country at the present time, most of whom cannot gain access to the memoirs in which these sections have been published, that this will be a sufficient reason for reproducing them in this connection. Not only in this report, but also in subsequent reports, we shall have constant occasion to refer to these sections, and the different groups of rocks. The sections were based on characters obtained from a careful study of the groups as exposed along the Missouri River, and it is here that their typical characters are found. As we depart from this center in any direction these characters are modified more or less. As we go southward into the Laramie Plains, Colorado, or New Mexico, these divisions are not as well defined, and Drs. Newberry and Leconte have very properly divided the whole cretaceous group, as there developed, into upper, middle, and lower cretaceous. Yet, to one familiar with the typical divisions as seen on the Upper Missouri, geographical extension never modifies them so that they do not still possess some traces of their original characters.

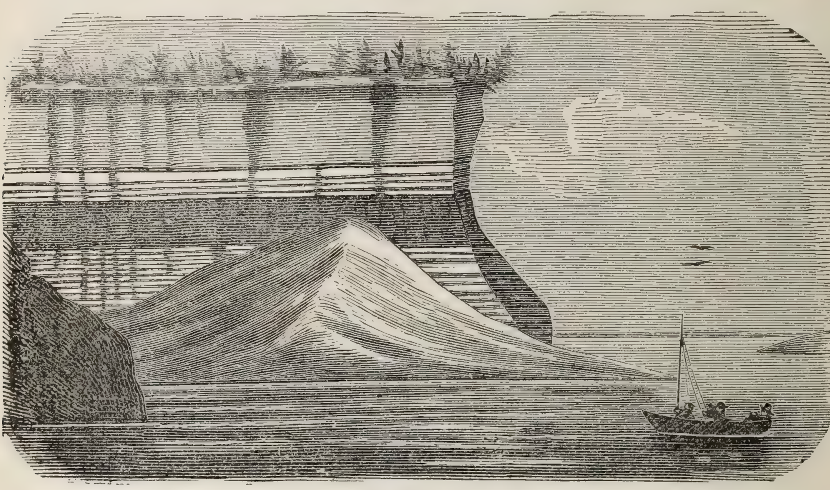
Formation No. 1, as seen all along the flanks of the mountains from the Big Horn and Wind River ranges to New Mexico, has never yielded a single characteristic fossil, and the lithological characters are quite different in many respects from those which are peculiar to the group, as shown near Sioux City and southward into Kansas. Again, in their southward extension, the division into upper and lower cretaceous groups would probably best accord with the facts as we know them at the present time.

General section of the cretaceous rocks of the Northwest.

		Divisions and subdivisions.	Localities.	Estimated thickness.	
				Feet.	
Upper series.	Fox Hills beds. Formation No. 5.	Gray, ferruginous, and yellowish sandstone, and arenaceous clays, containing *Belemnitella bulbosa*, *Nautilus Dekayi*, *Ammonites placenta*, *A. lobatus*, *Scaphites Conradi*, *S. Nicolletti*, *Baculites grandis*, *Busycon Bairdi*, *Fusus Culbertson*, *F. Newberryi*, *Aporrhais Americana*, *Pseudo-buccinum*, *Nebrascensis*, *Mactra Warrenana*, *Cardium subquadratum*, and a great number of other molluscous fossils, together with bones of *Mosasaurus Missouriensis*, &c.	Fox Hills, near Moreau River, near Long Lake, above Fort Pierre, along base Big Horn Mountains, and on North and South Platte Rivers.	500	*Senonien*, D'Orbigny.
	Fort Pierre Group. Formation No. 4.	Dark-gray and bluish plastic clays, containing, near the upper part, *Nautilus Dekayi*, *Ammonites placenta*, *Baculites ovatus*, *B. compressus*, *Scaphites nodosus*, *Dentalium gracile*, *Crassatella Evansi*, *Cucullœa Nebrascensis*, *Inoceramus Sagensis*, *I. Nebrascensis*, *I. Vanuxemi*, bones of *Mosasaurus Missouriensis*, &c.	Sage Creek, Cheyenne River, and on White River above the Mauvaises Terres.	700	Eq. upper or white chalk and Maestricht beds.
		Middle zone nearly barren of fossils	Fort Pierre and out to Bad Lands, down the Missouri, on the high country, to Great Bend.		
		Lower fossiliferous zone, containing *Ammonites complexus*, *Baculites ovatus*, *B. compressus*, *Helioceras Mortoni*, *H. tortum*, *H. umbilicatum*, *H. cochleatum*, *Ptychoceras Mortoni*, *Fusus vinculum*, *Anisomyon borealis*, *Amauropsis paludiniformis*, *Inoceramus sublœvus*, *I. tenui-lineatus*, bones of *Mosasaurus Missouriensis*, &c.	Great Bend of the Missouri, below Fort Pierre.		
		Dark bed of very fine unctuous clay, containing much carbonaceous matter, with veins and seams of gypsum, masses of sulphuret iron, and numerous small scales, fishes, local, filling depressions in the bed below.	Near Bijou Hill, on the Missouri.		
Lower series.	Niobrara division. Formation No. 3.	Lead-gray calcareous marl, weathering to a yellowish or whitish chalky appearance above, containing large scales and other remains of fishes, and numerous species of *Ostrea congesta* attached to fragments of *Inoceramus*. Passing down into light yellowish and whitish limestone, containing great numbers of *Inoceramus problematicus*, *I. pseudomytiloides*, *I. aviculoides*, and *Ostrea congesta*, fish scales, &c.	Bluffs along the Missouri, below the Great Bend, to the vicinity of Big Sioux River; also below there on the tops of the hills.	200	
	Fort Benton Group. Formation No. 2.	Dark-gray laminated clays, sometimes alternating near the upper part with seams and layers of soft gray and light-colored limestone, *Inoceramus problematicus*, *I. tenuirostratus*, *I. latus*, *I. fragilis*, *Ostrea congesta*, *Venilia Mortoni*, *Pholadomya papyracea*, *Ammonites Mullani*, *A. percarinatus*, *A. vespertinus*, *Scaphites Warreni*, *S. larvœformis*, *S. ventricosus*, *S. vermiformis*, *Nautilus elegans*, (?) &c.	Extensively developed near Fort Benton, on the Upper Missouri; also along the latter from ten miles above James River to Big Sioux River, and along the eastern slope of the Rocky Mountains as well as at the Black Hills.	800	Eq. lower or gray chalk (and upper gray sandstone) of British geologists. *Turonien* and *Cenomanien* (?) of D'Orbigny.
	Dakota Group. Formation No. 1.	Yellowish, reddish, and occasionally white sandstone, with, at places, alternations of various colored clays and beds and seams of impure lignite; also silicified wood and great numbers of leaves of the higher types of dicotyledonous trees, with casts of *Pharella (?) Dakotensis*, *Axinaea Siouxensis*, and *Cyprina arenarea*.	Hills back of the town of Dakota; also extensively developed in the surrounding country, in Dakota County, below the mouth of Big Sioux River, thence extending southward into northeastern Kansas and beyond.	400	

The names which are given to these groups, both in the cretaceous and tertiary rocks, are always provisional, and are intended as specific points around which to group such facts as may add to our own knowledge from year to year; and when it shall have been found that any of them have served their purpose, and are no longer needed, they will be dropped from the list. Objections may be made to the use of local geographical names, but they have been found by experience to serve our purpose best. In Nebraska the sandstones of the Dakota Group rest directly upon rocks of the age of the coal measures. Although they do not appear in full force until we reach a point near De Soto and beyond, yet remnants of the sandstones make their appearance within five or ten miles of Omaha at any point north of the Platte River. It is quite probable that they once extended all over Nebraska, passing across into Iowa, and how much further eastward we have not definite data to determine. The coal-measure limestones are thus exposed in northeastern Nebraska by the erosion of the cretaceous rocks. This is a very important matter in a practical point of view, for the sandstones of the cretaceous group are seldom of much value for building purposes, and the exposure of large areas of the carboniferous rocks in the most fertile portions of the State is a fact of inestimable value.

Fig. 1.



Chalk Bluffs, Cretaceous No. 1, near Blackbird Hill, Nebraska.

Along the banks of the Missouri River, on the Indian Reserve, is a lofty escarpment of yellow, rotten, coarse-grained sandstone, sometimes called Chalk Bluffs, from their whitish chalky appearance in the distance. They are from one hundred to one hundred and fifty feet in height, and about half way up, or at least fifty feet above the water, and as much from the top of this perpendicular wall, are carved out numerous Indian hieroglyphics, as pipes, canoes, various kinds of animals, rude representations of the Indians themselves, &c. The question at once arises, who carved them here? The Indians now living cannot account for them, and call the rocks "Medicine," a term which they apply to all things that are mysterious to them. The characters closely resemble those on their robes worn at the present day, and are doubtless emblematical of some important event in Indian history. These figures must have been carved here many centuries ago, when that portion of the escarpment was accessible from beneath in some way, all trace of which has been effaced by the water. Similar ones are still to be seen in other localities, especially in the mountains. A small creek, which flows into the Missouri a few miles below the "Running Water," has an Indian name which signifies "Where the dead have worked," from the fact, that upon the high chalky walls that form its banks are some of the same mysterious carvings. These soft sandstones, or chalky limestones, are well adapted for recording their hieroglyphical history.

But these rocks bear upon them far plainer characters than those described above, and characters which carry the history of events infinitely farther back into the past than any ever carved upon stone by human hands. Near the Blackbird Mission, and in other localities above and below this place, has been found a remarkable series of fossil plants embedded in the sandstones and quartzites, which has thrown much light upon the ancient flora of this region. These sandstones all belong to the lower cretaceous or chalk period, and it is now well ascertained that with the beginning of that era, began upon our continent the dawn of existing deciduous fruit and forest trees, as did also the present race of edible fishes, as the herrring, perch, &c. We find impressions of leaves in rocks, remarkably well preserved, representing the genera *Platanus*, *Populus*, *Fagus*, *Liriodendron*, *Sassafras*, *Magnolia*, *Ficus*, and others. Some of these plants indicate a warmer climate at one time in this region than at present, though hardly tropical, or, as Dr. Newberry has shown, not even sub-tropical, although on the Pacific coast species of the palm and cinnamon, indicative of a tropical climate, are found. It may be that when these rocks are more thoroughly studied, plants of a tropical or sub-tropical character will be found. I take pleasure in transcribing the following paragraph from Dr. Newberry's able report on these plants:

At the base of the cretaceous series in New Jersey, occur a coarse, soft sandstone and beds of sandy clay which contain a large number of fossil leaves, many of which, collected by Professor George H. Cook, of New Brunswick, by Messrs. Meek, Hayden, and others, have been submitted to me for examination. Unfortunately most of these leaves are inclosed in a material so coarse and friable that they have been much broken and are scarcely susceptible of accurate study. They form, however, quite a rich flora, which includes a number of species not yet obtained from the cretaceous beds of the West, with others that are apparently identical with some obtained by myself on the banks of the Whetstone Creek in Western Kansas. Among these plants is a beautiful conifer, generically new, as indicated by its cones, which are in a good state of preservation. The plants from this district have not as yet been carefully studied, and they form an attractive subject for future investigation. In the circumstances of their fossilization they resemble the plants of the West, and apparently indicate an invasion of the ocean, occasioned by a subsidence by which the limits of the continent were contracted, but to what extent on its eastern margin, we have no means of determining accurately.

By referring to the list of plants on a preceding page it will be seen that the cretaceous strata of the west coast include some forms not yet discovered in the Kansas and Nebraska beds. Among these, *Salisburia*, *Sabal*, *Cinnamomum*, &c., are indicative of a warm climate. Possibly these genera may hereafter be detected in the plant beds of Kansas, Nebraska and New Mexico, but as yet we have no intimation of their existence, and there is nothing now known in the cretaceous flora of that region which gives it a tropical or even sub-tropical character.

It will be remembered that this vegetation grew upon a broad continental surface of which the central portion was considerably elevated. This would give us a physical condition not unlike that of the continent at the present day, and it would seem to be inevitable that the isothermal lines should be curved over the surface somewhat as they are at present. It may very well happen, therefore, that we shall find the palms and cinnamons restricted to the western margin of the cretaceous continent. It will be seen by the notes now given of the tertiary flora of our continent that at a later date palms grew in the same region where these cretaceous plants are found, but cinnamon and other tropical plants seem to be entirely wanting in the tertiary flora of the central parts of the continent, while on the west coast both palms and cinnamons lived during the tertiary period as far north as the British line. We have, therefore, negative evidence from these facts—though it may be reversed at an early day by further observations—that the climate of the interior of our continent during the tertiary age was somewhat warmer than during the cretaceous period, and that during both the same relative differences of climate prevailed between the central and western portions that exist at the present day.

Near the entrance of the Big Sioux River into the Missouri the

Dakota Group disappears beneath the water-level, and is succeeded by a series of black, plastic, laminated clays, with lighter-colored arenaceous partings and thin layers of sandstone. Near the mouth of the Vermillion River the upper portion becomes more calcareous, and gradually passes up into the next group. This formation has been called No. 2, or Fort Benton Group. It is often immensely thickened in the vicinity of the mountains from the north line to New Mexico, but on the Lower Missouri, where it was first observed by geologists, it never reaches a thickness of more than one hundred and fifty or two hundred feet. In New Mexico it occurs as the most conspicuous of the cretaceous divisions, and along the line of the Kansas Pacific Railway, in Kansas, it has yielded large quantities of the most remarkable reptilian remains. In the chapter on the geology of that route I shall have occasion to dwell more minutely on the interesting facts connected with this group. On the Missouri River it has yielded a number of species of *Inoceramus*, *Scaphites*, *Amonites*, and some thin layers are made up of remains of the scales and teeth of fishes. Farther up the Missouri River, near the mouth of the Niobrara, and resting on these sandstones and clays, is a thick bed of chalky limestone, containing vast quantities of a small species of oyster, and a large bivalve, *Inoceramus problematicus*, which is identical in species, or closely allied with one found in many portions of Europe. Some remarkable forms of fishes, not unlike our shad or herring, also sharks' teeth, have been found in abundance. A few other shells have been described in various localities in this chalk, and all of them are of a strictly marine character Much of this limestone, though colored extensively with oxide of iron, is soft, and leaves a mark on a blackboard or cloth like our common chalk of commerce. It is also composed largely of infusorial remains, as distinctly shown under the microscope. This formation, as well as the sandstone, is very widely distributed over the plain country in Nebraska, Dakota, and Kansas, and its influence on the agricultural prosperity of these regions is very great. The fertility of the soil is largely due to the calcareous matter of the one mingled with the silica derived from the other. The bluff-like character of these chalky limestones, as shown along the channel of the Missouri from the mouth of the Niobrara to the mouth of White River, is well illustrated by Figure 2.

Fig. 2.

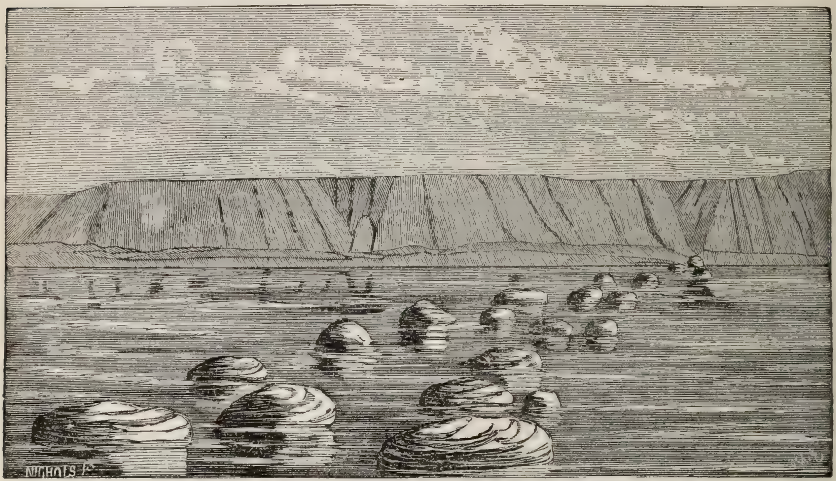
Bluffs of Niobrara Group, or Cretaceous No. 3.

This is one of the most interesting of the cretaceous divisions. It is found in some form wherever the cretaceous beds occur, from the north line to New Mexico, and probably much farther. As it is developed on the Lower Missouri, and southward through Nebraska, Kansas, into Texas and the Indian Territory, it contains thick, massive beds of chalky limestone. On the Kansas Pacific Railway, at Forts Hays and Wallace, this limestone is sawed into blocks of any desirable size with a common saw, and used for building purposes; but along the flanks of the mountains, or in the far West, it never reveals its chalky character. It is found in thin, slaty, calcareous layers, but universally characterized by the presence of the oyster, *Ostrea congesta*, and also some form of *Inoceramus*, or a few fish remains, but the little oyster is ubiquitous. We have spoken briefly of the lower series of cretaceous rocks, as shown in the section. In these three divisions there seems to be no well-marked line of separation, and the more we study them the more intimately do they seem to be blended together. We shall hereafter refer to the seams of coal that have been found in the Dakota Group; and we will state just here that one local bed of carbonaceous clay, which was used to some extent as fuel, was found in No. 2, on the Nebraska side of the Missouri, about thirty miles above Sioux City. In no other portion of the West have we ever seen anything that approached coal in this group.

The Fort Pierre Group begins to overlap the Niobrara Group below the mouth of the Niobrara, and above that point, although the river cuts deep down into the chalk limestone, and long lines of cone-like bluffs extend up nearly to the Great Bend, yet the distant hills on either side of the river show plainly the dark, shaly clays of No. 4. This formation covers a vast area of country, perhaps fifty thousand square miles or more, and wherever it prevails it gives to the surface the aspect of desolation. The entire thickness of the group is filled with the alkaline material which is so well known in the West, and wherever the water accumulates in little depressions and evaporates the surface is covered with a deposit of the salt varying from an inch to several inches in thickness. The water that flows through these clays is usually impregnated with these salts and thus rendered unfit for use. Although these clays seem to be so sterile, and in the dry season are typical of extreme aridity, yet they are by no means destitute of vegetation. The various species of *chenopodiaceous* shrubs and herbs that are peculiar to the West find their natural habitat in these clays, and grow most luxuriantly. The *sarcobatus* reaches its highest growth in this region. It is probable, however, that the country underlaid by rocks of this group will prove fertile when it can be irrigated. The somber appearance given to the country by the black clays is unfavorable to it. Nowhere except on the Upper Missouri have I seen this formation so well defined or so fruitful in organic remains. The two zones mentioned in the section may be said to exist geographically as well as geologically. At the Great Bend there is a large thickness of the strata filled with concretions that are made up mostly of an aggregate of fossils, as Ammonites, Baculites, &c. Near Chain de Roche Creek these concretions have been swept down into the Missouri by the swift current during the spring floods, and in the low water of autumn they present a picturesque appearance, as is shown in Fig. 3.

This fossil zone extends across the country in a nearly east and west direction. Passing above this point very few fossils, except here and there a baculite or bones of the *Mosasaurus*, are found for one hundred and fifty to two hundred miles, when another belt or zone of fossils extends across the country in the same direction. These zones undoubtedly represent certain depths of the waters in the great cretaceous sea, which were peculiarly favorable for the production and existence of animal life. Although the rivers cut deep channels through the different formations, we do not meet with the Fox Hills Group along the Missouri until we reach nearly up to the mouth of Cannon Ball River, yet fifty miles or

Fig. 3.



Concretions in Missouri River, near Chain de Roche Creek.

more before reaching that point it has overlapped the Fort Pierre Group. In traveling across the plain country westward from Fort Pierre we find it occupying the entire area. Very soon after passing west of the Big Cheyenne River the traveler will readily recognize its presence by the more cheerful appearance that it gives to the surface, as well as by the greatly increased growth of vegetation. The water is pure and good, and springs become quite common in the hills. In this group also there is a remarkable zone of fossils, exending across the country in either direction from the Missouri River. Near the mouth of the Cannon Ball River, the surface is covered with rounded concretions of rusty-brown arenaceous limestone, crowded with beautiful moluscous fossils. This belt is quite narrow and extends eastward toward the Coteau de Prairie, and westward between the Big Cheyenne and Grand Rivers, along the north side of the Black Hills. I have thus given the typical features which those groups assume on the Missouri River. As we recede from this region southward there are many modifications, especially lithologically; yet to one familiar with them they never lose all their characters, so that they cannot be detected. Like the human face, neither time nor distance can so change it that it does not retain some trace of its original features. In my explorations I have traced these groups over hundreds of miles in every direction, and I have no doubt that they extend from the Arctic Circle to the Isthmus of Darien; and that at some future period they will be so carefully studied at different points that they may be connected into one harmonious group. All the facts that I have been able to gather up to this time tend toward the unity and simplicity of the geology of the entire Rocky Mountain system.

If the reader has the patience and interest to follow me through this report, he will find frequent allusions to all these groups in the description of the geology of various localities. Some of these groups come to the surface very often, not unfrequently in unexpected localities, as is observed on the Yellowstone, where the fossiliferous beds of No. 4 are exposed in the channel of the stream for a distance of sixty miles. Nowhere south of the Missouri River have I seen any locality where a distinct line of separation could be drawn between the upper and lower series, and it is probable that this line will be best shown on the Upper Missouri of any portion of the West. The break here is quite plain, lithologically, and so far as the organic remains are concerned, our explorations have not yet been able to secure a single species that passes from one to the other. The next important feature in the geology of the West are the great lake basins, which seem to set in the older formations and in each other like dishes, and these are most properly called basins. The principal one is the Fort Union, or Great Lignite Group, which forms the transition group from the strictly marine condition of the cretaceous period to the epoch of the numerous fresh-water lakes which were scattered all over the country west of the Mississippi. Now that the attention of explorers has been called to this remarkable system of lakes, I have no doubt they will be found to have existed all over the western portion of the continent, from the extreme north to the far south. In the chapter by Dr. Newberry on the ancient lakes of the West there is a most graphic description, to which the reader is referred. The following general section conveys a clear idea of the different groups, so far as they were known, up to the time of its first publication in the proceedings of the Academy of Natural Sciences, December, 1861. As these groups will be frequently referred to in this report as well as succeeding reports, and as each year's explorations extends their area or adds new facts to our knowledge of them, it will be a matter of interest.

General section of the tertiary rocks of Nebraska.

Names.	Subdivisions.	Thickness.	Localities.	Foreign equivalents.
Loup River beds.	Fine loose sand, with some layers of limestone; contains bones of *Canis*, *Felis*, *Castor*, *Equus*, *Mastodon*, *Testudo*, *&c.*, some of which are scarcely distinguishable from living species. Also *Helix*, *Physa*, *Succinea*, probably of recent species. All fresh-water and land types.	*Feet.* 300 to 400	On Loup fork of Platte River extending north to Niobrara River, and south to an unknown distance beyond the Platte.	Pliocene.
White River Group.	White and light-drab clays, with some beds of sandstone and local layers of limestone. Fossils: *Oreodon*, *Titanotherium*, *Chœropotamus*, *Rhinoceros*, *Anchitherium*, *Hyænodon*, *Machairodus*, *Trionyx*, *Testudo*, *Helix*, *Planorbis*, *Limnœa*, petrified wood, &c. All extinct. No brackish-water or marine remains.	1,000 or more.	Bad Lands of White River under the Loup River beds, on Niobrara, and across the country to the Platte.	Miocene.
Wind River deposits.	Light-gray and ash-colored sandstones, with more or less argillaceous layers. Fossils: fragments of *Trionyx*, *Testudo*, with large *Helix*, *Vivipara*, petrified wood, &c. No marine or brackish-water types.	1,500 to 2,000	Wind River Valley; also west of Wind River Mountains.	?
Fort Union or Great Lignite Group.	Beds of clay and sand, with round ferruginous concretions, and numerous beds, seams, and local deposits of lignite, great numbers of dycotyledonous leaves, stems, &c., of the genera *Platanus*, *Acer*, *Ulmus*, *Populus*, *&c.*, with very large leaves of true fan palms. Also *Helix*, *Melania*, *Vivipara*, *Corbicula*, *Unio*, *Ostrea*, *Corbula*, and scales of *Lepidotus*, with bones of *Trionyx*, *Emys*, *Compsemys*, *Crocodilus*, *&c.*	2,000 or more.	Occupies the whole country around Fort Union, extending north into the British possessions to unknown distances; also southward to Fort Clark. Seen under the White River Group on North Platte River above Fort Laramie. Also on west side of Wind River Mountains.	Eocene (?)

"The passage from the brackish to the fresh-water beds in the oldest member of the tertiary of this region seems not to be marked by any material alteration in the nature of the sediments. Nor have we, so far as is yet known, any reasons for believing that any climatic or other important physical changes beyond the slow rising of the land, and the consequent recession of the salt and brackish water, took place during the deposition of the whole of the oldest member of the tertiary here, since we find a considerable proportion of the species of fresh-water mollusca ranging through this whole lower member. The principal difference between the fossils of its upper and lower beds consists in the gradual disappearance of strictly brackish-water types as we ascend from the inferior strata. The entire series of Nebraska tertiary rocks consists of three or four groups, three of which, at least, (and probably four,) evidently belong to separate and distinct epochs. They usually occur in isolated basins, but have, with one exception, all been seen in such connection as to leave no doubts in regard to their order of superposition."

The most important thought evolved from the study of this Fort Union Group is the fact, which we now believe is well established, that it contains the history of the growth, step by step, of a most important period of our continent. The area which it occupies is not yet known, but every year it is extended north, south, and west. It is also characterized by numerous beds of coal, or lignite as it was formerly called, and, so far as the Upper Missouri is concerned, most of the coal is true lignite. It is quite probable that the coal-making period began in the latter portion of the cretaceous era, and extended up into the tertiary. The observations of geologists in New Mexico and Utah point to the conclusion that large deposits of excellent coal occur in the upper cretaceous series. The field for minute study in this direction is immense, and we must await the results of future explorations before we can decide positively. Another interesting feature connected with this group is the splendid series of fossil plants which it has yielded, showing the existence during the early tertiary period, on these now treeless plains, of forests of almost subtropical character and luxuriance. Dr. Newberry, the celebrated geologist and botanist, has already described more than fifty species of plants from this group, which were collected on the Yellowstone and Missouri Rivers, many of them indicating forests of huge growth. Among them are not less than eight species of *Populus*, (poplars,) four species of *Platanus*, a sycamore, and a species of fan palm, the leaves of which must have had a spread of nearly twelve feet. The very interesting remarks of Dr. Newberry in this connection will be read with pleasure and instruction by every student of geology:

These fossils are generally well preserved in a calcareo-argillaceous rock of a light-drab color, upon which the leaves are delineated with a distinctness that renders them pleasant objects of study, as well as attractive specimens for the cabinet. They are usually detached with their petioles in such numbers and forms as indicate maturity, and a common cause of fall, such as an annual frost. The mollusks associated with them show that they were deposited in the sediment which accumulated at the bottom of some fresh-water stream or lake, and they are generally spread out so smoothly and so entire, that it is evident no violence, not even the action of a rapid current, could have been attendant upon their deposition. The sediment which inclosed them was usually very fine; a fact also indicative of a tranquil state of the water in which they were suspended.

The explorations of Dr. Hayden prove that this miocene lignite formation occupies the beds of extensive lakes, which filled deep basins on the surface of the continent when it had but recently emerged from the cretaceous sea. As has been remarked elsewhere, the lower members of the series contain a few estuary shells, showing the access of salt water at the period of their formation; but during the deposition of by far the greater portion of these beds, the water of the ocean was entirely excluded from the basins in which they accumulated. By tracing the outline of these deposits, Dr. Hayden has demonstrated that sheets of fresh water once covered surfaces in this portion of the continent which, in extent, rivaled the great chain of fresh-water lakes which exist elsewhere in our country at the present day. There is, therefore, every reason to believe that the remains of ligneous plants which compose this collection were derived from trees which grew along the shores of the lakes and streams of the tertiary continent; that then, as now, alternations of seasons prevailed, by which the foliage of these trees was periodically detached, and that, falling into the waters beneath, or near them, and sinking to the bottom, they were enveloped in mud precisely as leaves of our sycamores, willows, oaks, &c., accumulate at the bottom of our streams and lakes at present.

In comparing the group of plants here presented to us with those now living upon the surface of the earth, any one will be at once struck with the resemblance which they present to the flora of the temperate zone, and more particularly with that of our own country. In their study I have constantly found that on making comparisons with the plants of remote, and especially tropical countries, an entire want of resemblance or affinity at once discovered itself, and the only instructive comparisons made have been with the present vegetation of our country, that of the miocene tertiaries of Europe, and with the living plants of China and Japan. There is every reason to believe that future observations will make immense additions to this flora, and satisfactory comparisons and generalizations will only be possible when a far more complete series of its plants can be subjected to study. It is also true that as yet little other than the leaves of these plants have been collected and employed in the deductions made from them. From the character of the sediments which inclose these leaves, it is quite certain that the fruit and seeds are also preserved in the strata from which they were derived; but as they are less conspicuous and noticeable than the leaves, they are little likely to be found unless especially sought, and it will only be when they are made the special objects of search that they will be discovered, and lend their important assistance in the solution of the problems which the leaves present. For the want of such information as these organs would supply, some of the material included in the collection does not now admit of satisfactory classification, and the references of some of the leaves to the genera under which they are placed must be regarded as provisional and liable to modification by further research. Quite a number of these plants are, however, so largely represented in the collection, so well preserved, and so clearly allied to the genera and species with which we are familiar, that they constitute fair material from which to infer the general characters and affinity of the flora of which they form a part. In this list may be mentioned the *Glyptostrobus*, of which the stems, bearing the leaves of different forms, the cones and the sterile capitula are all present, and so closely resemble the specimens described by Professor Heer from the miocene of Europe, that they might also be considered the originals from which his figures were taken. The living analogue of this is *G. heterophyllus* of China.

The *Taxodium* now described is evidently a close analogue of *Taxodium dubium* of the miocene of Europe; differing from that well-known species only in the uniform rounding of the bases and summits of the leaves.

The fossil which has been doubtfully referred to *Sequoia Langsdorfii* would probably be regarded by foreign botanists as identical with that species, but for the reason given in the remarks upon that plant, it seems to me quite doubtful whether it was a *Sequoia*, and more probable that it was a *Taxodium* allied to our deciduous cypress.

The great fan palm (*Sabal Campbelli*) collected by Dr. Hayden seems to be a representative of *Sabal major* of the European tertiaries, and *Sabal palmetto* of our Southern States. From both these, however, it is distinguished by the large number of folds in the leaves, and from *S. major* by its flat, unkeeled petiole. The plate now given of this species represents the under surface of the leaf and petiole, but the collection also contains fragments showing the upper surface; and in the collections of the northwestern boundary commission are specimens obtained from the coast near Frazer's River, which exhibit in fine preservation the upper surface of the base of the leaf and a large portion of the petiole. From these latter specimens the species was originally described in the journal of the Boston Natural History Society.

The numerous species of *Populus*, of which figures are now given, will not fail to attract the attention of those whose interest runs in this direction. Several of them seem to be new to science, and show, for the most part, a greater affinity with the foreign poplars, *P. alba*, &c., than with the specimens more common on this continent, though a single one, *P. genatrix*, evidently belongs to the group of which our balsam poplar may be taken as a type. The little species described under the name *P. rotundifolia* presents some anomalies in form and structure as compared with most of our poplars, but its resemblance to another species contained in this collection, *P. elliptica*, and one contained in the collection of the Northwest Boundary Commission, which I described under the name *P. flabellum*, have induced me to class them together. Among living species it has a striking analogue in *Populus pruinosa* now growing in Songaria.

The several species of *Platanus* which the collection contains form a striking and interesting portion of this group of plants, and all seem to be quite distinct from the fossil species hitherto described, or any now living. Of our American sycamores, the leaves of *P. occidentalis* are much more toothed, while those of *P. racemosa* are more deeply lobed than any of these. *P. aceroides*, a species from the tertiaries of Europe, is more closely allied to our living ones than these seem to be. The largest and finest of those now described (*P. nobilis*,) in its smoothness of surface, crowded and parallel nervation, departs more widely from the typical species of *Platanus* than the others, and has more the appearance of a tropical plant. An extensive series of comparisons has, however, suggested no affinities closer than those with the living *Platanus*, and I have little doubt that in these leaves, of which the collection contains a large number, we have representatives of the noblest and most beautiful species of the genus.

Two of the species of *Corylus* present no characters by which they can be distinguished from the two now distributed over the temperate portions of our continent (*C. rostrata* and *C. Americana*,) and I have, therefore, not felt justified in considering them distinct. The *Carya*, figured, seems to me clearly to belong to this genus, and to be closely allied to one of our living species. The *Tilia* also is not far removed from *T. heterophylla*, one of our southern living species; while the *Negundo*, *Sapindus*, &c., seem to be the representatives of the genera and species now growing near the regions from which these fossils come.

From this flora, considering it the analogue and progenitor of that which now occupies our territory, we miss some important elements, and such as we may confidently expect will be supplied by future collectors. Among the most striking of these deficiencies may be mentioned *Acer*, *Quercus*, *Magnolia*, *Liriodendron*, *Liquidambar*, *Sassafras* &c., some of which, as we know, began their life upon the continent during the cretaceous period, and all of them were members of the miocene flora of the Old World. *Liquidambar*, *Quercus*, and *Magnolia* occur in the pliocene beds of New Jersey, *Magnolia* and *Quercus* in the miocene strata of the Mississippi Valley; *Fagus* also, which is wanting in the collection, has been obtained from the eocene by Mr. Lesquereux.

On comparing this flora with that of the miocene rocks of the west coast, we find *Smilax*, *Quercus*, *Salix*, *Oreodaphne*, *Acer*, and *Cinnamomum*—all of which are represented there—to be wanting here, while the *Sabal*, *Glyptostrobus*, and *Taxodium* are common to the two floras.

Until further collections shall be made from the plant beds of the Upper Missouri, it is evident that the deductions from the negative evidence of absent genera and species must be regarded as unsatisfactory, but it is a fact, not without its significance, that the genus *Cinnamomum*, which was largely represented in both the cretaceous and tertiary deposits of the west coast, and in the eocene of the eastern portion of the continent, should be entirely absent from the large amount of material collected by Dr. Hayden.*

We are at least justified in saying that from the evidence now before us, we must conclude that the flora of the banks of these inland lakes of the miocene period was that of a temperate climate, not warmer than that of the middle portion of our Southern States, and somewhat less warm than that of the eastern portion of our continent during the eocene period, or the western during the miocene age.

The notes on some of the species contained in the collection made by Dr. Hayden, *Sequoia Langsdorfii*, *Sabal campbellii*, *Onoclea sensibilis*, &c., have a bearing on the general questions to which reference has been made in the preceding pages, but the occurrence of an *Onoclea* among these miocene plants, and a species which I cannot distinguish from the living one, seems to me a fact of so much importance as to require some additional comments.

The fern frond found by the Duke of Argyle in the leaf beds of the Island of Mull, and figured by Professor E. Forbes in the Journal of the Geological Society of London, (vol. vii, 1851, p. 103; Pl. II, Figs. 2*a*, 2*b*,) and named by him *Felicites* (?) *hebridicus*, is unquestionably identical with this. The specimen from which the figures I have referred to were taken seems to have puzzled Professor Forbes somewhat, for he doubted if it was a fern; and Professor Heer, in his reference to the fossil plants of the Island of Mull, (Flor. Tert., Helvet., vol. iii, p. 314,) says: "The most remarkable species is *Felicites* (?) *hebridicus*, a fern which by its nervation differs greatly from those of the continent." All these facts give this fossil special interest, for, in addition to its relations to its living representatives—of which we cannot but consider it the progenitor—it adds another to the list of plants common to the miocene strata of Europe and America.

Of these—either representative or identical species—the number is now so great that they plainly indicate a land connection between the continents at that period; and since many genera, and this, with probably some other species, at that time common to the Old and New Worlds, have disappeared from Europe while they continue to flourish here, it would seem to follow that these were American types which had colo-

*If it is true, as now seems probable, that a large part of the Bellingham Bay deposits are cretaceous, that would account for this marked difference between the plants collected by Dr. Evans, Mr. Gibbs, &c., from those collected by Dr. Hayden.

nized Europe by migration; and that when their connection with their mother country was severed they were overpowered and exterminated by the present flora of Europe, which, as Professor Gray has shown, is mainly of North Asiatic origin.

The fact to which reference has just been made, viz, the occurrence of *Onoclea sensibilis* on the Island of Mull, off the west coast of Scotland, while it has not been found in the tertiary beds of other parts of Europe, is indicative, so far as it goes, not only of an American connection during the miocene period, but of an American origin for that species; and so, by inference, of the other genera and species common to the two continents during that epoch.

If this inference should be confirmed by future observations, we should then see how the eocene tropical or subtropical flora of Europe was crowded off the stage by the temperate flora of the miocene, which latter, accompanying a depression of temperature, had migrated from America, while the eocene flora retreated south and east, and is now represented by the living Indo-Australian flora—characterized by its *Hakeæ*, *Dynandræ*, *Ucalypti*, &c., &c., which form so conspicuous an element in the eocene flora of Europe. This theory would account for the presence of these tropical forms in the lower miocene of Europe, while, so far as yet observed, they are entirely absent from the miocene flora of America. In Europe a few of the eocene forms lingered behind in the grand exodus of that flora, and mingled with the more boreal and occidental barbarians by which the country was overrun, while in America these which we now call Asiatic forms never had an existence.

That this bridge between America and Europe was in a temperate climate is proved by the character of the plants which passed over it. On referring to a terrestrial globe it will be seen that by way of Greenland, Iceland, and the Hebrides, there are no very wide gaps to be spanned; but a connection by that route would carry us so far into the Arctic zone that none of the plants which we suppose to have made that journey could have withstood the cold if the climate had been the same as at present. We have conclusive evidence, however, that it was not so, for on McKenzie's River, Disco Island, on Iceland and the Island of Mull, we have, in the recurrence of parts of the very flora under consideration, proof, not only of a warmer climate at the far north during the miocene epoch, but that a part of the plants which formed the miocene flora of Europe actually did travel that road; at least, that they visited all these localities, and, in the buried remains of generations which were never to see the promised land, left us imperishable records of the reality of this migration.

That we cannot, without further study, assign a cause for this great change of climate in the northern part of our continent, is no proof against its existence, for the facts still remain; the cause of the phenomena is simply a thing to be learned. Several possible causes might be mentioned, but of those which suggest themselves, the deflection of the Gulf Stream seems to me the most natural, simple, and best to account for an elevation of the temperature of Greenland, Iceland, &c. Whether this cause would be sufficient to account for all the phenomena is at least doubtful. A diminution of the land surface at the north, if it could be proved, would help to solve the enigma. Probably several causes conspired to produce this effect, but they were apparently local, or at least terrestrial, as a cosmical cause, producing a general elevation of temperature on the earth's surface, would have given us a tropical flora on the Upper Missouri, whereas we find in the miocene flora there, as yet, really no tropical plants.

There is one other basin near the sources of the Missouri River which has already yielded many fossils of great interest, but which seems to be isolated from the others. This is what I have called the Judith basin, and inasmuch as it seems to be one of the ancient lake deposits, and characterized by a peculiar group of organic remains, I will designate the strata as the Judith Group. The sediments do not differ materially from those of the Fort Union Group, and they contain impure beds of lignite, fresh water mollusca, and a few leaves of deciduous trees. But the most remarkable feature of this group is the number and variety of the curious reptilian remains, of which we have only yet caught a glimpse. There is probably no portion of the West that furnishes such a harvest of fossil remains and instructive geological facts as the country bordering on the Missouri River, from the mouth of the Yellowstone to the foot of the mountains above the great falls of the Missouri; and as this country is reserved for examination the coming season, I will leave the obscurity which now invests it to be cleared in the next annual report.

All the groups of rocks now known to occur in the Northwest are well shown along the flanks and among the foot-hills of the mountains. The smaller ranges, as the Little Rocky, Judith, Bear's Paw, and Belt ranges, form the most interesting studies. As a rule, a central mass or nucleus of metamorphic rocks is elevated above the surrounding plain, and around these nuclei are exposed the Jurassic, triassic, carboniferous, and Potsdam rocks, in their order of sequence. But nothing short of a topographical survey, in connection with the geology, will make the structure of this region clear to the scientific world.

The Black Hills of Dakota will form one of the most interesting studies on this continent. There is so much regularity in the upheaval that all obscurity is removed and all the formations known in the West are revealed in zones or belts around the granitic nucleus in their fullest development. A careful detailed topographical and geological survey of this range would be a most valuable contribution to science. In all the western country I have never seen the cretaceous, Jurassic, triassic, or red-beds, the carboniferous and Potsdam rocks, so well exposed for study as around the Black Hills.

CHAPTER VIII.

*FROM OMAHA TO CHEYENNE.

In the preceding chapter I have given a brief review of the geological formations of the Northwest, as revealed by that grand natural section, the valley of the Missouri River. We are now prepared to proceed on our journey westward.

The city of Omaha is most beautifully located on the western bank of the Missouri River, on a second terrace, about fifty feet above the water-level of the river. Terraces of the kind alluded to form a peculiar feature along the Missouri River and its tributaries, and are found from the foot of the mountains to its mouth, and in many instances they seem to afford most beautiful natural sites for cities. I will not, at this time, enter into an explanation of the causes which produce these terraces, but simply remark that they perhaps indicate oscillations of level in the surface, or the gradual recession of the waters toward the sea, and that, far back in the past, each one of them has at one time formed the bed of the river. They also seem to indicate that formerly the Missouri carried to the ocean a vastly greater volume of water than at present. Another feature will at once catch the eye of the observing traveler, and that is the marvelous fertility of all this region. The wide grassy bottoms are black with rich vegetable matter to an almost indefinite depth, while the upland terraces and hills are covered with a deposit of yellow marl, varying from twenty to one hundred and fifty feet in thickness. There seems to be evidence that the ocean or a lake once extended up the valley of the Mississippi, and up the Missouri beyond the reach of tidal influences nearly to Fort Pierre, and that the myriads of mountain streams poured their fresh waters into the great arm of the sea, or estuary. These numerous streams, flowing through the soft marls, sands, and clays of the great plain country, mingling their sediments in the waters, and deposited them in the bottom of this estuary.

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*In chapters VIII to XIII inclusive, numerous extracts have been taken from the text of a volume entitled "Sun-Pictures of Rocky Mountain Scenery," and an article published in the proceedings of the American Philosophical Society, Philadelphia, February 19, 1869, by the writer. These papers necessarily have a very limited circulation, and as these official reports are designed for distribution far and wide among the people this will be a sufficient excuse for introducing them in this connection.

The channels of all the larger rivers had been marked out prior to this time, for we find that these superficial deposits reach their greatest thickness in the immediate valley of the Missouri River and thin out as we pass up the valleys of its tributaries on the east and west side, while they almost cease to appear near the mouth of White Earth River.

The question at once occurs, at what time did this geographical condition of the country exist? We believe that it forms a part of what is called the quarternary period in geology, which, though very modern, geologically speaking, really extended far back in the past before the existence of man on this continent, judging from the evidence we have been able to secure up to the present time. If we examine the numerous cuts, or washed bluffs, which we find everywhere, we shall discover a great variety of fresh-water and land shells, as Helices, Paludinas, Succinneas, &c., and here and there the remains of the mastodon and elephant. In the year 1867, while prosecuting the geological survey of Nebraska, under the General Government, I obtained from these marls fine specimens of the molar teeth of the *Elephas americanus* or American elephant, and the mastodon, *M. americanus.* These remains of gigantic extinct animals are mingled with those of animals existing in this region at the present time, such as rabbits, mice, gophers, beavers, buffaloes, deer, &c., which have been found in great quantities. Nearly all the shells are identical with living species which are abundant in some of the streams flowing into the Missouri and the Mississippi. In the banks of some of the little streams, oftentimes buried ten to twenty feet beneath the surface, are large accumulations of shells, as snails, fresh-water mussels, &c., while very few and perhaps none exist at the present time in the immediate vicinity. Sometimes, in the fine vegetable matter that accumulates along the Missouri River from the annual floods, can be seen bushels of minute snail shells, yet not a snail can now be found alive anywhere in that region. We account for this by some change in the physical conditions which were once very favorable for their existence and increase. The waters of the little streams were far clearer and purer than at present. Now, at certain seasons of the year, they become so charged with sediment that molluscous life cannot exist. This is the case with the Missouri River from the foot of the mountains to its mouth, and scarcely a shell can be found in its waters; but in some of its tributaries, as the Big Sioux, James, Vermillion, &c., that flow in from the north, there is the greatest abundance.

The traveler will very naturally inquire, why, with all this wonderful fertility of soil, these broad, grass-covered plains do not contain a suitable supply of forest trees. We will endeavor to answer this question in another place. He will find, as he travels over the State of Nebraska, that the time is not very distant when portions of the country will be covered with beautiful artificial forests, and we will attempt to show that this is only a restoration of conditions that once existed far in the geological past.

Before leaving the Missouri River I will refer briefly to an interesting phenomenon which I shall work up in detail at some future time. The proofs of glacial action in the West are not common or very remarkable in their character; still they are shown to a certain extent, not only in the mountains but also in the plains. Along the Platte River, below Omaha, and on the Missouri, near the city, the carboniferous limestones have had their upper surface so thoroughly smoothed by glacial action that they can be quarried out and used for caps and sills without any further finish to them. And the process seems to have been carried on with wonderful uniformity, for the upper surface seems to be as level as if it had been wrought with a plumb line. There are a few small grooves or scratches, and by means of a compass I ascertained the direction to be about 27° west of north, or about northeast and southwest. There seem also to be two sets of scratches crossing each other at different angles.

It would appear, from the evidence we have, that all the limestones underneath the yellow marl and pebble deposits around Omaha, and south to the Platte River, were smoothed or planed off by immense masses of ice passing over them, for wherever these superficial deposits have been stripped, the upper rocky layers are planed off with remarkable smoothness. In the mountains proper, the evidences of glacial action are not uncommon, especially on the sides of the deep valleys and gorges, but the causes were local and operated when the temperature of the climate was much lower than it is at present.

Westward from Omaha we wend our way among the rounded grassy hills which rise in wave-like undulations as far as the eye can reach in every direction. The first glance at such a scene strikes the stranger with astonishment at its wonderful beauty, but it soon becomes so monotonous that any flat plain or rugged mountain is a relief. About thirty miles to the westward the road passes out of the hills into the valley of the Platte, and the journey westward is one gradual ascent to the mountains, walled on either side by more or less abrupt hills or bluffs. Here we may stop for a while to discuss some of the more important geological features for the first one hundred miles of our route. The surface deposits over this area possess no small degree of interest, both in an economical as well as scientific point of view, but I have already sufficiently explained their character. They seem, however, to occupy a very large area in this portion of Nebraska, concealing almost entirely the underlying or basis rocks. The geology, therefore, becomes somewhat obscure, and can be studied only at a few outcroppings, from point to point. The principal exposures are along the Platte, where the river has cut a wide and deep channel through the surface of the country. The fact, however, that the strata are very nearly horizontal, that there are no upheavals nor mountain elevations to disturb the original positions of the beds, aids us much in our investigations. We believe that the whole of Douglas County is underlaid by the limestones of the upper coal measures, with perhaps a moderate thickness of the rusty sandstones of the lower cretaceous or Dakota Group lying above them in the western portion of the county. At the mouth of the Platte these coal-measure limestones are very conspicuous, and supply the greater portion of the building stones of this region. The dip, if any, is quite gentle toward the northwest, and at the mouth of the Elkhorn River the carboniferous limestones have passed beneath the water-level of the Platte, not to be seen again until we arrive at the eastern margins of the Rocky Mountains. Overlying these are the ferruginous sandstones which contain the impressions of deciduous leaves. Near the mouth of Elkhorn are some of the abrupt bluffs of this sandstone, and the soft, yielding nature of the rock has enabled the Indian to record on it his curious hieroglyphical history.

Fig. 4 illustrates the sandstone bluffs as they occur on Little Blue River in the southern portion of Nebraska.

The question often arises in the minds of visitors to this region, how the law of compensation supplies the want of fuel in the absence of trees for that use. Many persons have taken the position that the Creator never made such a vast country, with a soil of such wonderful fertility, and rendered it so suitable for the abode of man, without storing in the earth beds of carbon for his needs. If this idea could be shown to be true in any case, we would ask why are the immense beds of coal stored away in the mountains of Pennsylvania and Virginia, while at the same time the surface is covered with dense forests of timber? We now know

Fig. 4.

Cretaceous No. 1, on Little Blue River, Nebraska.

that this law does not apply to the natural world, and if it did, this western country would be a remarkable exception. The State of Nebraska seems to be located on the western rim of the great coal basin of the West, and only thin seams of poor coal will probably ever be found. But in the vicinity of the Rocky Mountains, in Wyoming and Colorado, coal in immense quantities has been hidden away for ages, and the Union Pacific Railroad has now brought it near the door of every man's dwelling.

These Rocky Mountain coal beds will one day supply an abundance of fuel for more than one hundred thousand square miles along the Missouri River of the most fertile agricultural land in the world. Every acre of land in Eastern Nebraska is already in possession of the thriving farmer, and some of the most beautiful farms in the West can now be seen there. Although comparatively new, it looks like an old settled country. Farm-houses and small villages meet the eye in every direction, and the great interest which the more intelligent and enterprising citizens have taken in tree-planting is covering the once naked hills with the most elegant artificial groves. The time is not far distant when Nebraska will be noted all over the world for the grandeur and beauty of its agricultural portions. Being composed entirely of plain country, with rocks of comparatively modern age, all holding a horizontal position, or nearly so, without a single mountain range within its boundaries, Nebraska can never be remarkable in any way for its mineral resources. It is true that it has its salt springs, which are annually becoming more important and valuable. These springs are located near Lincoln, the capital of the State, and the saline water flowing from them into Salt Creek has given character to quite an important tributary of the Platte for thirty miles or more. This stream flows through a most beautiful, rolling, fertile region, covered with splendid farms, and has a deep channel, with steep muddy banks, a kind of forbidden object. Not a being can drink its waters, nor until near its entrance into the Platte do they, by accession of little streams and springs, become sufficiently freshened for the use of animals.

The valley of the Platte is a natural avenue through the country, from the foot of the mountains to the Missouri, and all the earthy materials which could possibly have existed over this vast area, from the summits of the highest hills on either side, and I know not how much more, have, in the lapse of ages, been swept down into the Missouri River and then conveyed to the ocean, to be distributed over its bottom to form layers for the study of future geologists. We may arrive approximately at the number of square miles of sediment which have been removed from this valley. It is at least five hundred miles in length, and from bluff to bluff will average more than four miles in width for the entire distance. Taking this low estimate as a basis, we have two thousand square miles of area literally carved out and carried away. We cannot compute the thickness of the sediment at less than one thousand feet, and it is altogether probable that it was much more. This vast change gives evidence of the tremendous forces of nature that have been continually at work all over this region. West of the mouth of the Elk Horn River the valley of the Platte expands widely. The hills on either side are quite low, rounded, and clothed with a thick carpet of grass. But we shall look in vain for any large natural groves of forest trees, there being only a very narrow fringe of willows or cottonwoods along the little streams. The Elk Horn rises far to the northwest in the prairie near the Niobrara, and flows for a distance of nearly two hundred miles through some of the most fertile and beautiful lands in Nebraska. Each of its more important branches, as Maple, Pebble, and Logan Creeks, has carved out for itself broad, finely-rounded valleys, so that almost every acre may be brought under the highest state of cultivation. The great need here will be timber for fuel and other economical purposes, and also rock material for building. Still the resources of this region are so vast that the enterprising settler will devise plans to remedy all these deficiencies. He will plant trees, and thus raise his own forests and improve his lands in accordance with his wants and necessities.

These valleys have always been the favorite places of abode for numerous tribes of Indians from time immemorial, and the sites of their old villages are still to be seen in many localities. The buffalo, deer, elk, antelope, and other kinds of wild game, swarmed here in the greatest numbers, and as they recede farther to the westward into the more arid and barren plains beyond the reach of civilization, the wild nomadic Indian is obliged to follow. Geese, ducks, and other kinds of wild fowl, with now and then a stray antelope or red deer, may yet be seen, and the enterprising hunter may treat himself to a large amount of toil and a small amount of game. The underlying rocks, as far west as Columbus and beyond, though very seldom visible, are well known to belong to the chalk period, and consist of yielding sands, clays, and chalky limestones. These soft rocks, so readily crumbling under the atmospheric influences, have given a very gently-undulating and rounded appearance to the entire surface. One may travel for days in this region and not find a stone large enough to toss at a bird, and very seldom a bush sufficient in size to furnish a cane. Yet this region is settling up with emigrants with great rapidity; railroads are now in progress of construction, or are in contemplation, and villages are springing up in numerous localities. The principal ones at the present time are Frémont and Columbus. The latter, from its supposed central geographical position, has been regarded as the possible seat of the capital of the United States in case of its removal to the West.

Soon after leaving Columbus we cross Loup Fork or Wolf River, an important branch of the Platte, which rises in the Sand Hills, one hundred and fifty to two hundred miles to the northwest, and drains a large area of country. In the summer of 1857 I had the opportunity of following it up from mouth to source in connection with an expedition under the command of Lieutenant (now General) G. K. Warren, United States Army. Its lower portion passes through an extremely fertile region, but above the Pawnee Reservation the Sand Hills begin to monopolize the country and render it unfit for settlement.

We now pass the eastern shore of one of the most interesting and most wonderful of those great lake basins which are found all over the West from the Missouri River to the Pacific coast; there is no water in it at the present time, and its existence is only known to the student of geology. During the tertiary period it occupied an area of at least one hundred thousand, and very possibly one hundred and fifty thousand, square miles. It will thus be seen that our greatest northern lakes, of which we so proudly boast, are but ponds in comparison with some that once existed in this mountain region. The close observer will notice at once that he is passing into a district the rock formations of which are quite different from any that he has seen before. He finds, also, that he is passing beyond the signs of great fertility, luxuriant vegetation, fine farms, and fields of grain, to a comparatively arid, sterile region; still, the broad bottoms of the Platte are covered with a fair growth of grass, but the chances for the successful cultivation of crops of any of the cereals are very small. The soil becomes too thin, sandy, and arid for the growth of anything more than a scanty vegetation.

We might linger here for a moment and inquire into some of the causes that have produced this scantiness of vegetation and almost entire absence of trees over so large an area. There is quite a remarkable belt or zone of country along the eastern base of the Rocky Mountains, extending from the Arctic Sea far south to Mexico, upon which but a small amount of moisture ever falls. This has often been denominated the Great American Desert. In years past this belt was supposed to comprise the greater portion of the area lying between the Missouri River and the foot of the mountains, but every year as we know more and more of the country this belt becomes narrower and narrower, and as a continuous area it has already ceased to exist, even in imagination. There are, however, large portions of the country that are comparatively worthless and arid, which may be called barren or sterile. It is now pretty well understood that the cause of the absence of timber in this great region is want of moisture. A very clear explanation of this subject, and one which seems in accordance with the facts, is given by Professor Dana in Silliman's Journal, vol. 40, page 393. If we were to examine a rain chart we should find that where the forests are most luxuriant, as along the Atlantic coast in the southern portion of the Mississippi Valley, the greatest amount of rain falls annually—say fifty to sixty-five inches; and as soon as we approach any of the interior basins of the western continent, or any portion of this dry belt, we observe that the amount of moisture diminishes to thirty, twenty, fifteen, ten, and in some cases to as low as five inches, annually. Again, along the Missouri River, where the vegetation is quite extensive and the forest trees abundant, we have twenty to thirty inches of rain; but as soon as we pass to the westward three hundred miles we have but ten or fifteen inches. On the Pacific coast of Oregon and Washington, whose gigantic forests are celebrated all over the world, we find that from fifty-five to sixty-five inches of rain fall annually. We might multiply these illustrations, but the evidence seems to be conclusive.

There is another point that may be worthy of note here, and that is the prevailing impression among all the inhabitants of the West of a gradual change of climate by settlement and the cultivation of the soil. It is true, that over a width of one hundred miles or more along the Missouri River the little groves of timber are extending their area; that springs of water are continually issuing from the ground where none were ever known before; and that the distribution of rain throughout the year is more equable. Such being the case, time may work important changes, and settlements may at some time cause a large portion of that belt which has hitherto been regarded as given up to sterility to become of value for the abode of man.

The valleys of the Loup Fork and the Niobrara Rivers, although largely uninhabitable, are full of interest to the geologist. Located along these rivers is one of those grand cemeteries of extinct animals which have excited the wonder of intelligent men all over the world. Further to the northwest, on White Earth River, is another of these far-famed bone deposits. These two interesting localities bear such a relation to each other in the order of time and the relationship of the animals preserved in them, that they should be described in the same connection. I will therefore take the reader at once to the valley of White Earth River, near the southwestern base of the Black Hills, and there we shall behold one of the wildest regions on this continent. It has always gone by the name of "Bad Lands;" by the Canadian French as "*Mauvaises Terres;*" in the Dakota tongue, "*Ma-koó-si-tcha.*" These words signify a very difficult country to travel through, not only from the ruggedness of the surface, but also from the absence of any good water and the small supply of wood and game. In the summer the sun pours its rays on the bare white walls, which are reflected on the weary traveler with double intensity, not only oppressing him with the heat, but so dazzling his eyes that he is not unfrequently affected with temporary blindness. I have spent many days exploring this region when the thermometer was 112° in the shade and there was no water suitable for drinking purposes within fifteen miles. But it is only to the geologist that this place can have any permanent attractions. He can wind his way through the wonderful cañons among some of the grandest ruins in the world. Indeed, it resembles a gigantic city fallen to decay. Domes, towers, minarets and spires may be seen on every side, which assume a great variety of shapes when viewed in the distance. Not unfrequently the rising or the setting sun will light up these grand old ruins with a wild, strange beauty, reminding one of a city illuminated in the night when seen from some high point. The harder layers project from the sides of the valley or cañon with such regularity that they appear like seats, one above the other, of some vast amphitheater. It is at the foot of these apparent architectural ruins that the curious fossil treasures are found. In the oldest beds we find the teeth and jaws of a Hyopotamus, a river horse much like the Hippopotamus, which must have sported in his pride in the marshes that bordered this lake. So, too, the Titanotherium, a gigantic pachyderm, was associated with a species of hornless Rhinoceros. These huge rhinoceroid animals appear at first to have monopolized this entire region, and the plastic, sticky clay of the lowest bed of this basin, in which the remains were found, seems to have formed a suitable bottom of the lake in which these thick-skinned monsters could wallow at pleasure. As we pass higher up in the sediments, we find the remains of a great variety of land animals mingled with those that were aquatic in their nature. In a bed of flesh-colored marl which is visible for a great distance, like a broad band in the sides of these washed hills, thousands of turtles were imbedded, and are preserved to the present time with surprising perfection, the hard portions of them being as complete as when they were swimming about in these tertiary waters hundreds of thousands of years ago. They vary in size from an inch or two in length across the back to three or four feet. But one species has ever been discovered in this basin, and so far as we know these reptiles made up in numbers what they lacked in variety. Associated with the remains of the turtles, are those of a number of ruminants, all belonging to extinct genera, and possessing peculiar characters which ally them to the deer and the hog. Indeed, Dr. Leidy calls them ruminating hogs. Like the domestic species, they were provided with cutting teeth and canines, but the grinding teeth are constructed after the same pattern as those of all living ruminants. The feet of these animals were also provided with four toes as in the hog, and none of them possessed horns or antlers. They appear to have existed in immense numbers, and to have lived in great herds like the bison of the West. Remains of more than seven hundred individuals of one species have been already studied and described by Dr. Leidy. Their enemies were numerous wolves, hyænodons and saber-tooth tigers.

If we pass for a moment southward into the valleys of the Niobrara and Loup Fork, we shall find a fauna closely allied, yet entirely distinct from the one on White River, and plainly intermediate between that of the latter and of the present period; one appears to have lived during the middle or miocene tertiary period, and the other at a later time in what is called the pliocene. In the later fauna were the remains of a number of species of extinct camels, one of which was of the size of the Arabian camel, a second about two-thirds as large, also a smaller one. The only animals akin to the camels at the present time in the western hemisphere are the llama and its allies in South America. Not less interesting are the remains of a great variety of forms of the horse family, one of which was about as large as the ordinary domestic animal, and the smallest not more than two or two and a half feet in height, with every intermediate grade in size. There was still another animal allied to the horse, about the size of a Newfoundland dog, which was provided with three hoofs to each foot, though the lateral hoofs were rudimental. Although no horses were known to exist on this continent prior to its discovery by Europeans, yet Dr. Leidy has shown that before the age of man this was emphatically the country of horses. Dr. Leidy has reported twenty-seven species of the horse family which are known to have lived on this continent prior to the advent of man—about three times as many as are now found living throughout the world.

Among the carnivores were several foxes and wolves, one of which was larger than any now living; three species of Hyænodon—animals whose teeth indicate that they were of remarkably rapacious habits; also five animals of the cat tribe were found, one about the size of a small panther, and another as large as the largest wolf. Several of the skulls of the tiger-like animals exhibited the marks of terrible conflicts with the cotemporary Hyænodons.

Among the rodents were a porcupine, small beaver, rabbit, mouse, &c.

The pachyderms, or thick-skinned animals, were quite numerous and of great interest, from the fact that none of them are living on this continent at the present time, and yet here we find the remains of several animals allied to the domestic hog, one about the size of this animal, another as large as the African Hippopotamus, and a third not much larger than the domestic cat.

Five species of the Rhinoceros roamed through these marshes, ranging from a small, hornless species, about the size of our black bear, to the largest, which was about the size of the existing unicorn of India. No animals of the kind now inhabit the western hemisphere.

Among the thick-skinned animals were the remains of a mastodon and a large elephant, distinct from any others heretofore discovered in any part of the world. Dr. Leidy says that "it is remarkable that among the remains of mammals and turtles there are none of crocodiles. Where were these creatures when the shores of the ancient Dakotan and Nebraskan waters teemed with such an abundant provision of savory ruminating hogs?" During the tertiary period Nebraska and Dakota were the homes of a race of animals more closely allied to those inhabiting Asia and Africa now, and from their character we may suppose that during that period the climate was considerably warmer than it is at present. The inference is also drawn that our world, which is usually called the new, is in reality the old world, older than the eastern hemisphere.

Ever since the commencement of creation, constant changes of form have been going on in our earth. Oceans and mountains have disappeared and others have taken their place. Entire groups of animal and vegetable life have passed away and new forms have come into existence, through a series of years which no finite mind can number. To enable the mind to realize the physical condition of our planet during all these past ages is the highest end to be attained by the study of geological facts. It has been well said by an eloquent historian that he who calls the past back again into being, enjoys a bliss like that of creating.

We may attempt to form some idea of the physical geography of this region at the time when these animals wandered over the country, and to speculate as to the manner in which their remains have been so beautifully preserved for our examination. We may suppose that here was a large fresh-water lake during the middle tertiary period; that it began near the southeastern side of the Black Hills, not large at first nor deep, but as a marsh or mud-wallow for the gigantic pachyderms that lived at the time; that as time passed on it became deeper and expanded its limits until it covered the vast area which its sediments indicate. We cannot attempt to point out in detail all the changes through which we may suppose, from the facts given us, this lake has passed, during the thousands of years that elapsed from its beginning to its extinction, time long enough for two distinct faunæ to have commenced their existence and passed away in succession, not a single species passing from one into the other. Even that small fraction of geological time seems infinite to a finite mind. We believe that the great range of mountains that now lies to the west of this basin was not as lofty as now; that doubtless the treeless plains were covered with forests or grassy meadows upon which the vast herds of gregarious ruminants cropped their food. Into this great lake on every side poured many little streams from broad valleys, fine ranging ground for the numerous varieties of creatures that existed at that time. Large numbers of fierce carnivorous beasts mingled with the multitudes of gregarious ruminants, constantly devouring them as food. As many of the bones, either through death by violence or natural causes, were left in the valleys, they would be swept down by the first high waters into the lake and enveloped in the sediments at the bottom. As the gregarious ruminants came down to the little streams or by the shores of the lake to quench their thirst, they would be pounced upon by the flesh-loving Hyænodon, Drepanodon, or Dinictis. It was probably near this place also that these animals would meet in fierce conflicts, the evidences of which remain to the present time in the cavities which the skulls reveal; one of these, of a huge cat, shows on either side the holes through the bony covering which had partially healed before the animal perished, and the cavities seem to correspond in form and position with the teeth of the largest Hyænodon.

The remains of those animals which, from their very nature, could not have existed in great numbers, are not abundant in the fossil state, while those of the ruminants occur in the greatest abundance and are widely diffused in the sediments not only geographically, but vertically. The chances for the preservation of the remains of a species seem to depend upon the number of individuals that existed. The remains of ruminants already obtained comprise at least nine-tenths of the entire collection, while of one species, portions of at least seven hundred individuals have been discovered. We might take examples from the animals that exist in this region at the present time that would illustrate the point. The wolves watch the deer, antelope, and other feebler animals as they go down to the little streams for water, and all over the wide bottoms their skeletons are distributed in a more or less perfect condition. Whenever a bison becomes too feeble by disease or age to offer a successful resistance, the wolves soon dispatch him, and his bones are left bleaching on the ground. In most cases these animals when pursued betake themselves to the water, where they are not unfrequently drowned, or dispatched on a sand-bar or island. Annually, thousands of buffaloes, in attempting to cross the Missouri River and some of its large tributaries on the ice as it is breaking up in the spring, are drowned. For many days their bodies are seen floating down the river by Fort Union or Fort Clark, and lodging on some of the islands or sand-bars fill the air with the stench of their decay. In the spring of 1857 thousands of their bodies floated down the Kansas River past Fort Riley and were carried into the Missouri River. These animals are often mired in the marshes or the muddy shores of lakes or streams in great numbers. We know what vast numbers of the mastodon have been preserved in the Big Bone Licks of Kentucky, and of the Irish elk in the bogs of Ireland. We might instance hundreds of examples to show how easily these animals, roaming and feeding along the numerous streams flowing into some great lake, could be transported in part or entire into the lake, and sinking to the bottom would be enveloped in the muddy sediments.

There is another interesting feature in regard to these remarkable fossils, and that is the beauty and perfection of their preservation; the bones are so clean and white and the teeth so perfect that, when exposed upon the surface, they present the appearance of having bleached only for a season. They could not have been transported from a great distance, neither could the waters have been swift and turbulent, for the bones seldom show any signs of having been water worn, and the nice sharp points and angles are as perfect as in life. I have dwelt thus long on the details of this great lake basin, not only on account of the universal interest that invests it, and the wonderful treasures of the past which it has revealed to the world, but because its history is applicable in the main to the numbers of the other fresh-water lake basins of the geological past which are distributed throughout the Rocky Mountain region.

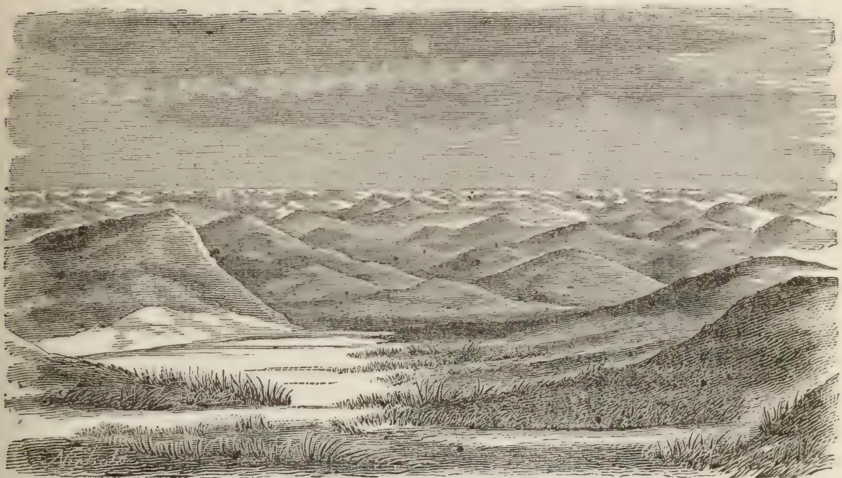
Before leaving this subject, there is another interesting topic of inquiry: why such a beautiful series of vertebrate remains should be so perfectly preserved in this lake deposit, and yet the remains of other forms of animal and vegetable life be almost entirely absent. The sediments seem to be peculiarly adapted to the preservation of a full series of documents bearing upon the history of those times. And yet in the older beds, where the mammalian remains are most abundant, only one small species of snail, a land shell, is found preserved. Where is the evidence of the swarms of fishes that must have filled the streams and lakes of that time? Of the vegetable life, if any existed, only now and then a fragment of silicified wood is found, and that, too, in the latest deposits. I am prepared to believe that the broad plains were, even at the time of the existence of these animals, as treeless as at present, yet I am quite unprepared to explain the almost entire absence of vegetable remains. We know that fresh-water shells, much like those existing in the little clear streams of the present time, as well as some remains of fishes, are found in some limestones on the summits of hills near Pinos Spring on the northern rim of the lake.

Another interesting question occurs to me in this connection, how was it that a complete fauna, comprising more than forty species of animals, was introduced upon the earth, lived through its legitimate period, entirely perished or was swept out of existence, and an entirely new fauna, comprising about the same number and variety, was again introduced in the same region? It, too, lived out its period of existence, which must have been hundreds of thousands of years, and yet every one of this group of animals disappeared from the globe, leaving nothing behind to tell the tale but fragments of their bony skeletons, accidentally enveloped in the sediment at the bottom of an estuary or lake.

It will be seen at a glance that this is a fruitful topic for speculation, and I leave it with the reader. Some of the species of animals found in the latest deposits seem to have lived very nearly up to our present period. The horns of a deer and the bones of a sand-hill crane have such a modern aspect that the thought arises, where was man when these animals were roaming over this region? Recent investigations show quite conclusively that man was an inhabitant of Europe cotemporaneously with many of the extinct animals of the quarternary period, but it is doubtful whether we have ever found any evidence that he lived at a very remote period on this continent. Indeed, so far as we know at present, the West is singularly silent as to the existence of man in what are now understood as pre-historic times.

But let us move our camp further south and toward the Platte Valley again, and on our way just glance at a desolate and almost barren but interesting region called the Sand Hills. They cover an area of about twenty thousand square miles on both sides of the Niobrara River, and are composed of loose, moving sand, which is blown by the winds into round, conical hills with considerable regularity. As far as the eye can reach the surface presents the appearance of a multitude of round tops, some of them scooped out by the whirling winds so as to resemble craters. These sand hills have been from time immemorial a favorite resort of the buffalo, which feeds upon the scanty but very nutritious grasses in the little valleys and intervals among these hills. There is, for the most part, an abundant supply of water in the little lakes that are scattered throughout this region. Some of them are alkaline in the highest degree, and the fresh can be detected from the salt lakes by the presence or absence of vegetation in and around the borders. These hills are sometimes protected from the winds by a considerable growth of vegetation on their sides, especially the "Yuccas, or Spanish Needles," which seem to grow luxuriantly in these almost soilless regions. No portion of the country is so barren or soilless as to be destitute of its peculiar vegetation, and even those portions that appear most sterile

Fig. 5.



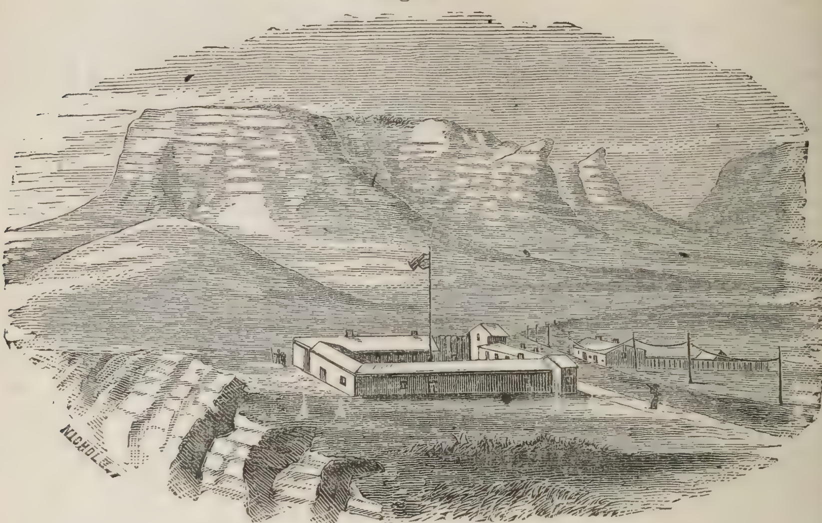
Sand Hills on the Niobrara River.

have some forms which flourish there best, and would perhaps perish if transported to a richer district. In the "Bad Lands" the soft, succulent cactus, which draws most of its nourishment from the atmosphere, often covers the bald, dome-like hills as if it would conceal their nakedness and sterility. These large moving bodies of sand are not uncommon in the West; in the North Park there is quite a large area completely covered with them, and as the surface reflects the light of the sun's rays, they appear in the distance like some extensive lake. Near the Mosca Pass in the San Luis Valley is another group of sand hills which is quite conspicuous. The winds seem to delight in playing their antics in these places, throwing up the sand in the most beautiful wave-like furrows. Sometimes the strong winds that sweep over these vast plains will fill the air with a storm of sand so as to impede the traveler's progress for the time, and again they whirl it in circular columns far out of sight.

We shall now continue our way up the valley of the Platte with a good deal of rapidity. The country is monotonous, and yet now and then a fact of some interest might be gathered. We soon pass into what is called the alkali district, where the ground is covered in places with a white efflorescence, which looks in the distance like snow. If the traveler were to ascend the high hills that border the valley and cast his eyes in every direction, he would see nothing but a gently rolling prairie, without a tree or shrub as far as they could reach. No cozy farm-houses, with all the signs of cultivated fields, greet the eye; no groves of timber dot the landscape. For more than two hundred miles along the valley of the Platte it would be difficult to find wood enough to kindle a fire. Fuel for the supply of Fort Sedgwick and the city of Julesburg, during the winter of 1865–'6, when it was in its glory, was hauled from the mountains near Denver, Colorado, a distance of more than two hundred miles, at a cost from one to two hundred dollars per cord.

The surface of the country is sometimes weathered by atmospheric agencies into peculiar fantastic shapes. The rock formations are entirely composed of the whitish and yellowish-white clays, marls, and sandstones of the more recent beds of the great tertiary lake basin.

Fig. 6.



Fort Mitchell—Scott's Bluff.

The most striking examples are in the vicinity of Scott's Bluff and Chimney Rock, which have been noted landmarks for years. The surface is here washed out into the form of domes, towers, churches, and fortifications, and it is hardly possible to persuade oneself that the hand of art has not been busy here. Chimney Rock shoots up its tall, white spire from one hundred to one hundred and fifty feet. The strata are perfectly horizontal, and, therefore, we may infer that the surface of the whole country was originally on a level with the summit at least, and that these landmarks are monuments left after erosion. These picturesque views south of White River are not extensive, although on both sides the north and south forks of the Platte they occur in certain localities. A few fossil turtles and the bones of some huge animal, probably the elephant or mastodon, have been washed from the bluffs. At Antelope Station, near Pine Bluffs, about four hundred and seventy miles west of Omaha, a collection of curious bones was taken out of a well sixty-eight feet below the surface, which were at once regarded by the people in the vicinity as human remains. These bones were distributed throughout the country and furnished many a sensational paragraph for the daily press. About two years ago, Professor Marsh, in visiting this country, made inquiry for them, and succeeded in obtaining a few fragments, from which he determined the existence of a small species of horse, which must have been originally about two or two and a half feet high.

From a mass of sediment sixty-eight feet below the surface, ten feet in diameter and six feet thick, Professor Marsh obtained a quantity of fragments of bones belonging to seventeen different species of animals. In it were those of four varieties of the horse family, one of which was as large as the living domestic horse; one or two species of rhinoceros;

an animal allied to a camel, and one resembling a hog; two carnivores, one about as large as a lynx, the other greater than any living carnivore, even the lion. Such a quantity of remains, so varied in species and stowed away in so small a space, has never been found before.

What a world of fossil treasures could be gathered if the whole area south of the Platte and between the Platte and White Rivers were carefully examined by men of science! And even then, only those which are exposed to the eye of the geologist by atmospheric agencies would be found, while the great mass of rock material which underlies the entire surface is equally filled with them, and undoubtedly contains some forms that will never be recorded in the annals of science.

If we now take the cars we shall pass over a similar plain country until we reach Cheyenne, an important and rather remarkable city, near the foot of the mountains, five hundred and sixteen miles west of Omaha, one thousand two hundred and fifty nine miles east from Sacramento, and one hundred and ten miles north from Denver. This city is located in the open plain, near Crow Creek, a branch of the Platte, the hills ascending gently back to the mountains proper, which are plainly visible from the town. On the 4th day of July, 1867, there was but one house in this place; within three months there were at least three thousand inhabitants, with the bustle and confusion of a city of ten thousand. It is now improving rapidly, and promises a successful future. Again, looking at the profile section of the railroad, we find that Omaha is nine hundred feet above the sea-level. At Cheyenne we have reached an elevation of five thousand nine hundred and thirty-one feet, yet the ascent has been so gradual over an apparently level plain, that we have not for a moment realized that we were ascending at the rate of nearly ten feet to the mile. If the traveler has observed closely, he will have seen that nature had already performed most of the work of the road, and that there was not much more to be done but to lay the track, and that for the entire distance of more than five hundred miles there were no rock beds to blast.

Before concluding this chapter, we will throw a momentary glance back upon the ground over which we have just passed. Nebraska may be divided into two portions—agricultural and pastoral. The eastern part contains some of the most beautiful, gently-rolling, fertile agricultural lands in America, the very garden spot of the country. But the western part is a treeless, almost waterless plain; yet, thick, low, sweet, nutritious grasses cover the entire surface, and for the raising of large herds of stock, as horses, cattle and sheep, this country is admirably adapted. Not more than fifteen to twenty inches of moisture fall here annually; the snows of winter are very light and soon pass away, the winds rapidly gathering them into the valleys or gorges, leaving vast areas entirely bare. The grasses, instead of decaying as in all countries with a humid climate, slowly dry up, retaining all their nutritious qualities, and thus continue until April or May, so that all kinds of stock thrive throughout the winter in the open fields without other care than that of the herdsman. The time cannot be remote when Western Nebraska, also Wyoming and Colorado, will be appreciated as a wool-growing region far surpassing any portion of the East.

In the autumn many of the streams of the plains dry up for the most part, although at long intervals water may be found. In ascending the valley the water of Lodge Pole Creek will appear and disappear almost like magic. Here we find it a swift-running stream several yards in width, and then for a considerable distance nothing is to be seen but its dry and dusty bed. Even the broad Platte has so far forgotten itself for several seasons as to cease to be a running stream. It is not uncommon for a river to be considerably larger toward its source than at its mouth. Many of the important streams that flow from the Black Hills into the Missouri are lost on their way through the plains. This is especially the case with rivers in the arid regions of New Mexico and Arizona.

CHAPTER IX.

OVER THE FIRST RANGE.

In the preceding chapter I have endeavored to convey some idea of the remarkable character of the great fresh-water lake basin which occupies so great an area in Nebraska. We have seen that the carboniferous limestones pass beneath the lower cretaceous sandstones near the mouth of the Elk Horn, about thirty miles west of Omaha; that the cretaceous rocks extend westward about eighty miles farther, where they are overlapped by the marls and clays of the White River Group. These form an unbroken mass to the very margins of the first range of mountains west of Cheyenne. Up to this point our ascent has been so gradual that it is hardly perceptible to the common observer, and yet the grade has been upward at the rate of nearly twelve feet per mile. If we examine the excellent profile of the Union Pacific Railroad constructed under the supervision of the distinguished engineer, General G. M. Dodge, we shall find that Omaha, the eastern terminus of the road, is nine hundred and sixty-six feet above tide-water. At Cheyenne, which is five hundred and seventeen miles west of Omaha, the elevation is six thousand and seventy-two feet; west of Cheyenne the ascent increases with great rapidity; at Sherman Station, near the summit of Laramie range, the height is eight thousand two hundred and forty-two feet; so that within a distance of thirty-three miles we have a difference of elevation of two thousand one hundred and seventy feet, or an ascending grade of nearly sixty-six feet per mile. A profile section across the country east and west from the Missouri River, from the north line to Mexico, would show the same graded ascent, illustrating with great clearness the long-continued but regular upheaval of the great original plateau west of the Mississippi. If we were to stand on the spot where the city of Denver is located, five thousand four hundred and thirteen feet above the sea, and look to the north, south, or east, we shall see only a broad, apparently level plain, with no perceptible ascent; but turning our eyes to the westward, the ranges of the main Rocky Mountain chain seem to rise abruptly out of the plain, showing very clearly that when the crust of this great original plateau had been stretched to its utmost tension, these lofty ranges burst through the superincumbent sedimentary strata as the germ breaks through the hard-trodden earth above it. The series of ridges which are so well exposed along the base of the mountains show plainly that all the formations from the summits of the lignite tertiary to the granites extended uninterruptedly across the area now occupied by these ranges prior to their elevation, and probably up to the close of the cretaceous epoch, and possibly somewhat later. This important fact is better illustrated near Denver than at any point north along the main traveled routes, because the mountains form a portion of the great watershed of the continent, while the Laramie range west of Cheyenne is a detached portion, seldom rising over eight thousand feet above the sea. This range, however, forms a perfect anticlinal, and must be studied in detail in order that its beauty and regularity may be understood; and althoguh I regard it, as well as the Black Hills of Dakota, a more perfect illustration of my theory of the elevation of the Rocky Mountain system, yet it is not as conspicuous an example to the casual observer as he lofty ranges west of Denver.

From Cheyenne to Granite Cañon, near the summit of the first range, the grade of ascent is greater than between any other points along the Union Pacific Railroad. The distance is about nineteen miles, and the difference of elevation between the two places is one thousand eight hundred and sixty-seven feet, or a grade of more than ninety feet per mile. The recent tertiary beds lie close up to the flanks of the mountains, over a belt of several miles, affording accomparatively easy transition from the newer formations to the granite nucleus.

For hundreds of miles either north or south of this line it would be difficult or perhaps impossible to build a railroad across the mountains, but here nature seems to have provided an easy inclined plain to the very margin of the mountain summit. The ridges are very nearly concealed, while on either side they can be seen as formidable as anywhere along the eastern base.

Close up to the sides of the mountains this more recent formation is composed of water-worn boulders and pebbles, varying much in size, but as we recede eastward toward the plain they disappear for the most part. The same is the case with the drift, which shows clearly that the causes which led to the deposition of these beds operated in the vicinity, and the materials are derived from the mountains near by.

On either side of this inclined plain, north or south, we can see the upturned edges of the different sedimentary rocks in this region. Between Granite Cañon and Cache la Poudre, about forty miles along the foot of the mountains, not only is the scenery rugged and grand to the eye, but the complications of geological structure are very interesting. There seems here to have been a jog in the minor ranges which compose the aggregate range, and several of these smaller ones disappear in the plains. The belt of upheaved ridges is here ten to fifteen miles wide, revealing all the sedimentary rocks, from the carboniferous limestones to the most recent tertiary beds. The peculiar brick-red color of the sandstones, which are supposed to be of the triassic age, gives a singular appearance to the scenery. We have here the carboniferous limestones resting upon the granites; then a series of brick-red sandstones inclining at different angles, with beautiful grassy valleys between the ridges, and little streams cutting through nearly at right angles; then a thin group of sand and marls, which may be Jurassic; then the whole series of cretaceous beds with their characteristic remains; then the lignite tertiary beds with coal, all conforming to each other, and all inclining from the mountains at different angles. All the beds just alluded to perfectly conform to each other, but the light-colored rocks, which most attract the eye of the traveler at Cheyenne, do not conform, and were of course deposited subsequent to the uplifting of the mountain ranges. We can see, therefore, that the eastern flanks of these mountains formed a shore line for a great fresh-water lake.

If we make our investigations still north of this line, we shall find, for two hundred miles or more, that these recent beds jut up against the older sedimentary beds, and in many places rest upon the granites. Sometimes the whitish rocks have been removed by erosion, so as to expose the older ones, but near Laramie Peak they entirely conceal all but the granites. In many places these recent beds are found high up on the flanks of the mountains, in a nearly horizontal position, as if many of the outer peaks were mere islands in this great lake, much like those in Salt Lake at the present time. I have said enough here to show the reader that from Cheyenne to the summit of the first range he is passing over a thick shore deposit of an ancient lake, which once covered a vast area, very much larger than that of any of our fresh-water lakes of the present day. The cuts along the road do not show all the formations in this vicinity. The traveler must stop a day and wander away from the line of the road, if he would make his geological observations complete.

The recent beds rest directly on a stratum of white limestone of carboniferous age. This limestone is very useful to the citizens of the Territory, inasmuch as it can be burned into lime of the finest quality. The walls of houses plastered with it are as white as snow, and it is a great favorite with masons. The supply is inexhaustible, although it is not exposed anywhere along the mountains in any very great thickness.

These limestones are regarded as of the same age as those we saw at Omaha and along the Platte, and if so, they must have been concealed over this long distance, at least five hundred miles, and had it not been for the upheaval of these mountains, would never have been exposed to the eye of man.

Before leaving that portion of Wyoming Territory which lies east of the first range I will say a word in regard to its agricultural and pastoral resources. The soil is fertile and must be quite productive where it can be irrigated. Better pasturage does not exist in the known world, and sooner or later this portion of the Territory must become celebrated not only for the quantity but the quality of its stock. Along under the mountains and in the valleys of the little streams that flow therefrom, as the Lodge Pole, Chugwater, and others, very little snow falls all winter, and the grass remains very nutritious until late in the spring. All the roots and most of the cereals can be raised on the east side of the mountains. The city of Cheyenne cannot hope for a permanency until the surrounding country is settled by a thriving farming population, and the time is not far distant when the valleys of Crow Creek, Pole Creek, and others will be occupied with farm-houses and the bottoms covered with excellent crops. Plans have already been made by the citizens for irrigating large areas of the upland. The healthful change which will at once be produced in the country will encourage others, until all the available farming land will be brought under cultivation, and the prosperity of the Territory will be rendered certain. However valuable rivers may be to a country, and however great the impulse a railroad may give to the first settlement of a region, the basis of all permanent prosperity seems to rest upon the products of the soil.

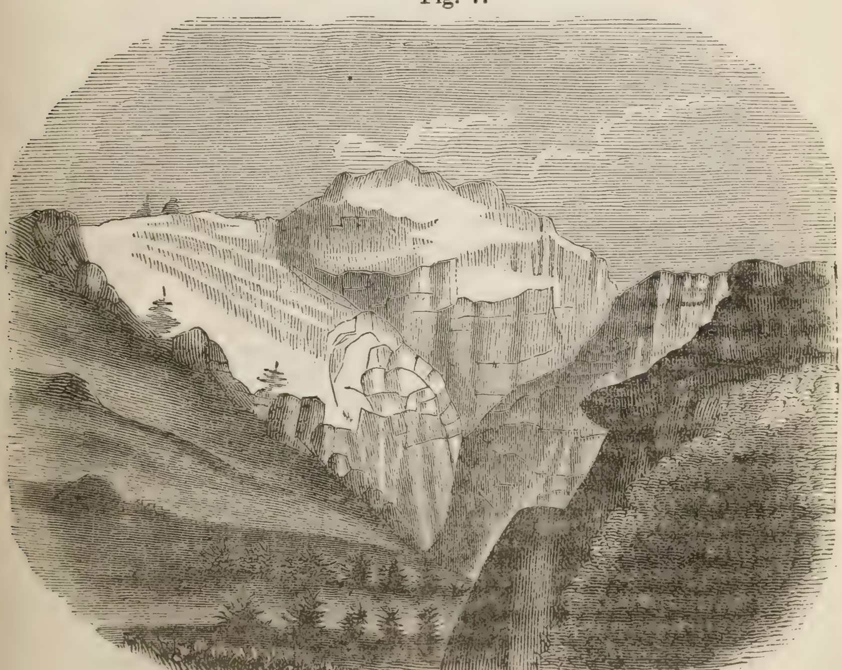
The science of geology continually shows how entirely dependent upon causes which were in operation many ages ago are the most practical results of man. Like the ripe fruits which so many pluck from the tree, and enjoy without a further thought, so these important benefits are accepted by mankind, and how few are thoughtful enough to inquire from whence they come!

The stupendous erosive agencies which have in most cases scooped out deep valleys just at the foot of the mountains, have left this portion remaining of the inclined plain which I have described as extending from Cheyenne to Granite Cañon, and underlying the western shore of a great lake, and thereby rendered it possible for the Pacific Railroad to pass over the range, saving to its enterprising builders millions of dollars.

We shall endeavor to show along the line of the route that this great road was really constructed in far past geological times, and it was left for man to discover and avail himself of the advantages of the secret workings of nature. The summit of this range presents some scenery which is quite unique and remarkable, differing in many of its features from that at any other point along the road. It would well repay the tourist, and especially the artist, to spend several days here; the air is delightfully exhilarating and cool, the water pure as crystal, and all parts easily accessible. The little streams are full of fish, especially trout, and game is moderately abundant; black-tailed deer, red deer, and antelope are yet found, though becoming less abundant every year, and with two or three kinds of grouse and woodcock will reward the sportsman.

The rocks which compose the nucleus of this range are granites, or, inasmuch as they present a great variety of texture, I have chosen to call them granitoid. Sometimes the rocks are made of large crystals of feldspar and quartz, with very little or no mica, forming a coarse feldspathic granite; sometimes the constituents will be quite uniform, and a fine-grained, compact, and most durable rock will be the result. Again, some constituent of iron will prevail, and disintegration is rapidly effected by atmospheric agencies. The surface of this range is literally paved with small fragments of rock, and the natural roads that are made in the mountains are macadamized with feldspar. Building materials are abundant, and as extensive as the mountains themselves. On each side are massive hills of syenite, which look in the distance like the ruins of some gigantic old castle. This is a close, compact, massive granite, rather fine-grained and susceptible of polish, much like the Scottish syenite.

Fig. 7.



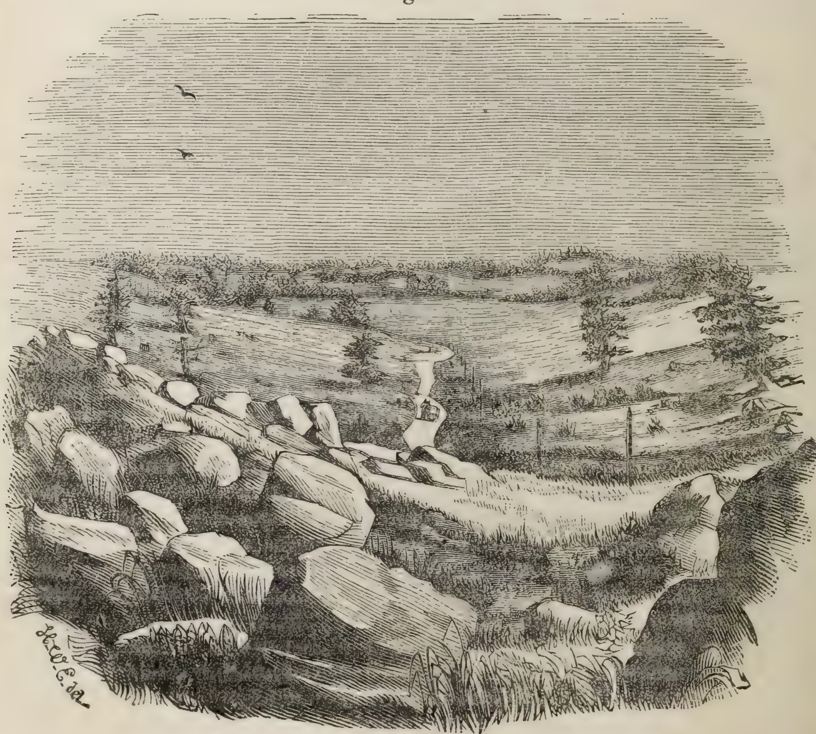
Granite Cañon, near Syenite Station, Union Pacific Railroad.

The directors of the Union Pacific Railroad contemplate transporting this beautiful rock to Omaha, to construct with it the piers of the bridge across the Missouri River. I believe it will prove as durable and far more elegant, on account of its brighter color, than Quincy granite.

The cuts along the road furnish excellent opportunities for rock study. They are, as it were, portions carved out of the crust, and we can thus obtain more accurate notions of its geology than in any other way. The surface has often been so changed by erosion that the loose material that has fallen down the sides of natural gorges, in almost all cases, obscures, to a greater or less extent, the true character of the rocks, and I have found these excavations of the greatest importance in my examinations, correcting many an erroneous view.

Figure 7 is an excellent illustration of a cañon through the different kinds of granite. On the right side of the tract the rock has been disintegrated for a considerable distance down by moisture, and the feldspathic crystals project from its sides with great distinctness. A heavy vein of quartzite is also distinctly shown. In the distance we catch a faint glimpse of one of these massive granite piles, which are so well shown in Figure 9. The character of the surface of this range of mountains, which is about twenty to thirty miles in width, is also well shown. Large areas are comparatively level, and covered with a thick growth of grass, with here and there a thin grove of pines. These trees are hardly ever more than from fifty to sixty feet high, and seldom more than two feet in diameter at the base. Further up in the higher ranges the white spruce and several other species of coniferous trees are found.

Fig. 8.



Virginia Dale, Summit Laramie Mountains.

Figure 9 forms an excellent rock study, and it is a fine illustration of the style of weathering of the feldspathic granites. These massive piles, like the ruins of old castles, are scattered all over the summit of the Laramie range, and the difference in texture of the rock is such as to give a most pleasing variety, hardly any of these piles being alike. These rocks were once angular masses, probably nearly cubical blocks, and they have been rounded to their present form in the process of disintegration by exfoliation. Nature seems to abhor all sharp corners or angles, and with her the curve is the line of beauty. Time wears off all the sharp points in thin, spherical layers year after year. Skull Rock is another example of the tendency to wear into singular shapes. This rock, which has given name to one of these striking rock masses, has been peeled off, coat by coat, by the fingers of Time until it presents a very close resemblance to a human cranium. If we were to descend the beautiful valley of Dale Creek we should find the scenery even more romantic, and the granites worn into more fantastic forms. There is one portion of this valley which has long been celebrated for the beauty of its scenery, and known to the country as Virginia Dale.

The swiftly-flowing stream winds its way through the over-hanging rocks, which sometimes run up a thousand feet or more, with nearly vertical sides, and among these massive granite piles are grassy, oval, park-like areas, which must become at some future period favorite places of resort. The character of the scenery and the style of weathering of the rocks are well shown in

Fig. 9.

Granite Rocks, Sherman Station, Laramie Mountains.

Sherman Station, situated on the summit, is well known as the highest point over which the railroad passes between Omaha and Salt Lake Valley, and appropriately bears the honored name of the Commander-in-chief of the Armies of the United States.

We might linger for a time here and admire the beautiful and unique scenery which is unfolded to us on every side. We shall not meet with its like again in any other part of the West. Long's Peak, with its double spires, rises above the limits of vegetation into the regions of perpetual snow, more than fourteen thousand feet above the level of the sea. All around are less lofty cones, many of them so covered with pines that they look black and somber in the distance. Far to the southwest are the snowy ranges that surround the North Park, and in the intermediate space are groups of lower peaks or cones, rising like steps to the higher ranges. There is an interesting thought just here as to the real origin of these granitic, ruin-like piles that give the peculiar distinction to the plateau surface of the Laramie Mountains. I believe it is entirely due to erosive forces, which have operated here on a gigantic scale, and these cones and natural temples are the monuments that are left to tell the tale. I am convinced that the surface was at one time at least on a level with the highest of them. How much more has been removed it is now impossible to tell, but I am convinced that comparatively few geologists have fairly estimated the immensity of the time required and the vastness of the amount of material removed from the surface by erosion.

Three miles west of Sherman we cross the head of Dale Creek, a small stream which flows through a wide, gorge-like valley in the granitic rocks. Spanning the valley is a bridge six hundred and fifty feet in length, and one hundred and twenty-six feet above the little stream. This bridge, which is well worthy of examination, forms one of the most beautiful structures of the kind along this road, and always attracts the attention of the traveler, who looks down from it upon a beautiful grassy valley, through which winds a small stream, the whole walled in with massive granite, like that before described. After crossing the Dale Creek bridge we descend rapidly to the plains. On the west side of the mountains we pass across the inclined edges of formations which appear to be counterparts of those already alluded to on the east side. We find the sandstones resting upon the granite, and inclining at a greater or less angle westward; we also find the whitish and yellowish-white limestones of the carboniferous period; also the red sandstones, which have usually been regarded as Triassic, though I suspect that the upper portion, at least, is Jurassic; then come loose red sands, extending a considerable distance into the plains. If we continue on toward the Big and Little Laramie Rivers, we shall find the cretaceous beds, in full development, in a nearly horizontal position, and about thirty miles still farther west the coal beds of the tertiary period are seen.

But before we commence our general remarks in regard to this mountain range let us linger for a time among the singular and grotesque forms which nature has hewn out of the sandstones on this western slope. Here we may study some excellent illustrations of the wearing away of sandstones through atmospheric agencies. We wish as far as possible to present to the reader type examples of the influence which the atmosphere, in its varied phases, has in shaping the features of the landscape.

We have illustrated some of the granitoid rocks of the mountain's nucleus which have been metamorphosed by heat. Figure 9 is exceedingly instructive in many points of view. The rock itself is a moderately fine-grained sandstone, and varies in color from a yellowish white to a light brick-red, and is probably of Jurassic age. No organic remains have ever been found in the sandstones, although I have traced them along the mountain sides from our north line to Santa Fé. The reason why I call them Jurassic is, that a bed of limestone, which inclines from the flank of the mountain higher up, seems to hold a lower geological position, and contains the remains of crinoids, which Professor Agassiz refers to the genus *Apiocrinites*, which is Jurassic. To this place has been given the name of Dial Rock, on account of the peculiar dial-shaped form into which one of the columns has been worn. We see at a glance that these rocks are stratified; that they hold a nearly horizontal position; that they stand out in the plains nearly isolated, although in the immediate vicinity are other equally fantastic forms, covering quite an extensive area. Where are the intermediate portions of the rock out of which these singular monuments have been carved by the chisel of time? These level plains, covered now with grass and wild sage, were once on a level with the summits of these sandstones at least, while the vast mass of sandstone which filled up the general level has been swept away, who knows where? Who can estimate the forces that have wrought this mighty work, or the immensity of the time that it required? How many myriads of ages have the winds and storms beaten against the sides of these rocks, gnawing out the cavities and giving them the fantastic shapes they now possess? Every year smaller portions crumble off and are mingled with the soil below, and in time all these remnants of the past will be removed. It will be noticed that the larger mass is worn into a form that can easily be imagined a human face, and an American might fancy he saw in it some resemblance to that of the Father of his Country.

It is not an uncommon thing for the rocks of all textures in this country to weather into the forms which call to mind human beings and animals.

Fig. 10.

Triassic sandstones, west slope, Laramie range.

These sandstones also afford a fine illustration of what is called irregular layers of deposition, and the materials are supposed to have been brought here and deposited in turbulent waters. If we were to study the actions of currents of water along our streams, or of the waves of the sea-shore, we should continually find examples of the deposition of sandy material over an inclined plain; sometimes on one side of a ridge or elevation, and sometimes on the other. Now, if this sand were molded into rock, these layers of deposition would show distinctly this same irregularity. Not far distant from this point is another group of these weathered sandstones which show still more clearly these irregular layers. The softer portions have been worn away, causing each thin layer to stand out of the sides of the rocks with great distinctness. Sometimes the thin layers incline in one direction, sometimes in another. These sandstones vary in height from fifty to one hundred and fifty feet. On their summits the eagles are fond of building their nests, where they will be inaccessible to their human enemies. Before closing our description of Figure 10, I ought to allude to the wild sage bush, which so peculiarly characterizes these almost treeless plains. We are here more than seven thousand five hundred feet above tide-water; at this elevation we find a species of sage which takes the place of the one on the plains east of the mountains. It is called *Artemisia tridentata* on account of its small, three-toothed leaf. It grows about the same size and very much resembles the other species. This sage, as well as two or three kinds of shrubs peculiar to the high places, are well shown in the figure.

We have now described briefly the different sedimentary formations as they incline on each side of this mountain range. It may be well to remind the reader that this range is an excellent illustration of the plan of development of these mountains. We find a series of formations inclining from the eastern slope of the mountains; we pass over the range and we again find the corresponding portions dipping in an opposite direction over the western slope. We at once come to the conclusion that these formations at some former period extended uninterruptedly across the area now occupied by the granitic rocks, and that the intermediate portions have been removed by erosion. Then the query arises, at what time were these events brought about? It seems to me it must have occurred as the surface was slowly emerging from the waters of the ocean. As the bottom of the ancient sea along the line of this mountain range slowly arose, the waters became shallow, and they would be more easily disturbed by the winds and the erosive forces be proportionately increased, and if the rocks arose above the sur face the waves would dash against their sides and prove still more effective. The sediments would be wafted away and deposited in some other part of the ocean, to enter into the composition of more recent rocks.

The Laramie range, extending from a point near Long's Peak northward to the Red Buttes on the North Platte and the Black Hills of Dakota, form the most simple and complete examples of true anticlinals on a gigantic scale that I have ever met with in my explorations. These ranges are less complicated with basaltic outbursts than any others. Some of the peaks, like Laramie Peak, are quite lofty, but as a general rule they are low mountains, and for the most part composed of a nuclei of massive red feldspathic granites inclosed on each side with true gneissic strata. All these mountain ranges require a few more detailed examinations than I have ever been able to give them, but the statements that I have here made will, I think, prove to be mainly correct.

CHAPTER X.

THE LARAMIE PLAINS.

In our last chapter we descended the western slope of the first mountain range to a broad, open expanse of mountain prairie known as the Laramie Plains. This great area might be called a park; it is enclosed on three sides by extensive mountain ranges, but on the west its limits are not well defined, inasmuch as no mountain ranges of any importance intervene until we come to the Wasatch range, in Utah. It is usually understood to extend westward almost to the Medicine Bow River, and thus comprises an area about fifty miles from east to west, and one hundred from north to south, the Laramie range or Black Hills forming the eastern boundary. As we ride on the cars through the plains, these mountains, with their comparatively uniform and gently sloping sides, seem for many miles to bend around so as to inclose us within their walls. On the south side are the Medicine Bow Mountains, which are far more formidable and lofty than the others; indeed, the ranges this side are quite irregular and fragmentary, and are known by different names, as Sheephead Mountains, Elk Mountains, &c. Many of these lofty peaks and ranges have not yet been explored geologically or geographically, and these magnificent fields are ripe and waiting for the harvest of science. The far West is vast, but the laborers are few.

Before proceeding, we might for a moment trace to their sources in the mountains some of the beautiful rivers that wind their way through the plains. We shall find to our surprise that, although we have crossed a range of mountains the highest along the line of the road, we are still in the great valley of the Platte in which we started on our journey.

The main branch of the North Platte rises in the range of mountains which forms the north side of the Middle Park, very near Long's Peak. It takes a course a little west of north, flows through the middle of the North Park, cutting its way through immense cañons between the North Park and the Laramie Plains. It then continues nearly a north course, through tertiary as well as cretaceous rocks, to its junction with the Sweetwater, where it bends around to the east, so that near the Red Buttes its course is nearly southeast until it reaches the main Platte, near longitude 101°.

The Sweetwater, which is the principal branch of the North Platte, rises in the southern end of the Wind River Mountains, and flows nearly east and unites with the North Platte near Independence Rock. These streams flow through nearly every variety of geological formation which occurs in the West. From the junction of the Sweetwater to the Red Buttes it flows through granite, carboniferous limestone, red beds, Jurassic marls, and White River tertiary beds; and from the Red Buttes through lignite tertiary to a point about one hundred miles northwest of Fort Laramie. There the White River tertiary beds overlap the lignite tertiary, and then continue to the forks of the Platte.

The Medicine Bow and the two Laramies are important branches of the North Platte, and take their rise in the lofty, snow-capped mountains on the south side of the Laramie Plains. The region north of the North Platte is mostly a vast sage plain, and but few small branches flow in from that direction, but a multitude of small streams cut deep channels through the sides of the Laramie range and flow into the North Platte.

From Red Buttes to Fort Laramie, a distance of one hundred and fifty miles, many beautiful little streams rise in the Laramie range and pour a good volume of water into the Platte. These creeks occur every few miles, and in their passage from the mountain they have not only worn a deep channel in the steep side of the mountain, sometimes one thousand feet or more in depth, but they have also scooped out a wide, deep valley, which affords the best of pasture-ground for stock in summer, and warm, sheltered places in winter.

The main branch of the South Platte rises in the range of mountains which bounds the west side of the South Park, and flows about northeast to Cache à la Poudre, and there bends around slightly toward the east and joins the main Platte. The little branches that flow from the mountain sides are very numerous, and each one cuts a tremendous channel through the sides of the mountain, affording most excellent sections of the strata for the geologist. Nearly all the branches that rise in the plains have very wide valleys, but are mostly dry, especially in the latter part of summer and autumn. Although the Platte River is never navigable at any season of the year, yet the area drained by it is immense, being nearly three hundred thousand square miles; and yet it is one of the minor branches of the Missouri River.

The South Platte flows through the different formations along the flanks of the mountain; and in its course through the plains cuts the lignite tertiary for fifty miles or more, when the White River tertiary overlaps the plains to the junction.

These brief remarks are intended principally to show by the geography the gigantic scale upon which everything in this western country is planned; that even the district drained by the Platte and its branches is larger than all New England, New York, and Pennsylvania.

Myriads of little streams rise in springs on the summits of all the mountain ranges, and, flowing down the sides, gash out deep gorges, which afford most splendid sections of the rocks for the study of the geologist. And as for beautiful scenery, there is no limit to it. If we were to trace these streams to their source in the mountains, through gorges and chasms, into beautiful oval grassy valleys, up the precipitous flanks where they expand in numerous little branches, rushing and tumbling over the rocks, we should involuntarily pronounce each one at the time more grand, more beautiful, and more instructive than any we had ever seen before. It is impossible to describe to the reader the pleasure one enjoys in wandering among these mountain valleys, climbing the almost vertical cliffs and studying the almost unlimited variety of forms which the masses of rock present. Then, too, the vegetation, seen in summer, has the green, fresh appearance that is so inviting and grateful; the grass, flowers, and trees, all wear that healthy look which is only to be met in the mountains. Although the Laramie plains are at too high an elevation ever to become noted for their agricultural resources, yet the few attempts to raise certain crops have met with moderate success.

In the summer of 1868 a few farmers in the valley of Rock Creek, along the line of the old stage road, succeeded in raising some very good vegetables, as potatoes, turnips, cabbage, &c., and they would have remained there contented, had they not been driven away by the Indians. But it is doubtful if these plains will ever become a favorite abode for farmers, though for the raising of stock I believe they are unsurpassed. Horses, cattle, and sheep have already been raised here of the finest kind, and in the beautiful sheltered valleys they find the most secure retreats from the severity of the winter's cold. Thousands of tons of excellent hay can be cut every year along the bottoms of any of these streams.

There is a beautiful view of the plains proper, as seen in the valley of the Little Laramie, near Sheephead Mountain. We see here the meanderings of the little stream; the fringes of cottonwoods, willows, and a few shrubs in the immediate bottom, the level, lawn-like terraces covered with a thick carpet of grass, and gradually ascending to the hills on either side. The entire surface has been so perfectly softened down by time that the beauty of the scene is perfect. It is true, the plains are not at all times as uniformly smooth as this view would indicate. Not unfrequently the surface is rugged in places; masses of sandstone or limestone with steep sides rising in the midst of the plains—monuments left after the action of the waters that have smoothed down these beautiful landscapes. It would seem that they are left to aid us in reconstructing the geography of past geological times.

Near the middle of these plains, on Cooper's Creek, are some quite remarkable exhibitions of the chalk cliffs of the middle cretaceous period, in which are oyster-shells, fish scales, and the bones of a huge Saurian reptile. A little farther to the west is a long line of yellow sandstone bluffs two hundred to three hundred feet high, forming beds of transition or passage between the cretaceous and tertiary periods; and still farther west are more rugged hills in which are found beds of coal. We see, too, everywhere indications of the action of water on the surface of the plains. In many places rounded boulders of all sizes, from the minute pebble to a mass two or three feet in diameter, are found scattered profusely over the ground. Sometimes these rocks accumulate in vast quantities on the side of a hill, literally paving it; then again in long lines or rows, as if they had been carried by swift water or dropped from an iceberg. Everywhere in the vicinity of the mountains are abundant indications that the last act in the drama was the existence of large bodies of water everywhere among the mountains, which must have come from the mountains themselves, inasmuch as the drift material indicates a local origin. We may suppose that prior to the present period the temperature of the climate was very much lower; that vast bodies of snow and ice accumulated in the mountainous portions of our continent, and as the climate became more mild, the ice and snow slowly melted, transporting icebergs filled with rocks all over the plains, and when one of these vast icebergs would lodge and melt, the accumulations of worn rocks and debris would be great. In almost all cases the slope of the hill opposite the mountain range is the one covered with the debris, as if the mass of ice in floating down passed over the summit of the ridge and lodged on the opposite side. But it would be impossible for us to linger in all these pleasant places; entire volumes could be written illustrating the details of the geology of these plains; our only object is to gather along our route such facts as will illustrate our views and link our story together.

Before we again start on our way westward, we ought to take a glance at the North Park, which is only about fifty miles to the southwest of Fort Sanders. The journey is quite easily made in two days, and even in one day on horseback, which is by far the best method of traveling in this mountainous region. In August, 1868, I made a tour to the North Park with a small party of Army officers, and I shall not soon forget the scene of beauty that was opened to my vision from the summits of the mountains surrounding the park. I was the more desirous of visiting this region because so little was known in regard to it, and, although my visit was short and my examinations necessarily limited, I had the satisfaction of giving to the world the first accurate knowledge ever obtained by personal investigation of the geology of that interesting region.

Our course from Fort Sanders was nearly southeast, up the Big Laramie River, toward its source in the mountains. The geology of the plain country through which the Big Laramie flows is very similar to that of the Little Laramie, about fifteen miles to the westward. There are comparatively few exposures of the basis rocks, on account of the superficial drift which covers all this country. Still we find along the banks of the river, near the stage station, the same black plastic cretaceous clays with *Ostrea congesta* and a few remains of fishes; also the chalky marls; and about two miles above, the long high ridges, on either side, extending up for several miles, composed of the rusty yellow sands and sandstone of the lower cretaceous. The dip of these beds is very gentle, hardly perceptible to the eye.

The Big Laramie is a very clear stream, about fifty yards in width and averaging about two feet in depth, easily forded in most places. Like most of the western streams, the difference between high and low-water mark is very great. In spring and early summer, when the snows of the mountains melt, these streams become formidable rivers. The soil along the bottoms appears to be very good; the grass grows quite heavily, and hundreds of tons of hay are cut here by the settlers for winter use. The grazing is excellent, and numerous ranches have been started all through the valley for the purpose of raising stock. Even at this season of the year a great variety of flowers covers the surface. The *Compositœ* and *Leguminosœ* prevail in numbers, and yellow is the dominant color. As we approached the foot-hills of the mountains the transition beds appeared on the ridge, rocks of more recent date having been swept away by erosion. Fragments of pudding stone and rusty-colored masses of sandstone were scattered here and there; then beneath them were exposed about four hundred feet of variegated arenaceous layers of uncertain age, perhaps Jurassic; then a little higher up the side of the mountains were revealed the red beds, fifteen hundred feet or more in thickness, presenting wonderfully picturesque scenery. All these beds seem to have been lifted up in a nearly horizontal position, so that they present lofty escarpments, sometimes cone-like or pyramidal in shape, revealing each layer in the order of succession. The harder layers yielding less readily to atmospheric influences, project out from the sides, adding much to the novelty of the view. Most of the beds incline from the flanks of the mountains at various angles, 3°, 8°, 15°, and then continue along the river, winding for twenty-five miles among the mountains almost to the foot of the snow-covered peaks.

On either side can be seen a number of syenitic nuclei, but I did not find the unchanged rocks so clearly in contact with them that I could define their relation to each other.

Before reaching the mountains we passed a series of alkaline lakes, which are simply shallow depressions, receiving the drainage of a small area without any outlet. From these shallow lakes the water is evaporated, so that in the autumn the bottoms are dry and covered with a white incrustation which looks much like water in the distance. One of these lakes still contained water and seems to have a fair supply at all seasons. It is almost a mile in length and half a mile in width. In the spring these lakes are quite large and are filled by the overflow of the branches of the Big Laramie, which are greatly swollen by the melting snows. Great quantities of fish are swept into these lakes from the neighboring streams, and in the autumn the water becomes so alkaline by evaporation that the fish die in great numbers along the shore. It is a curious fact that not a single trout has ever been taken in any of the branches of the North Platte, unless a few have been caught in the Sweetwater, while the branches of the South Platte are filled with them.

After entering the foot hills of the mountains, the Big Laramie and its branches wind their way through the narrow valleys or gorges formed by the anticlinals and synclinals produced by the upheaval of the unchanged rocks.

All the lower beds are more or less arenaceous and of a brick-red color, with only three layers of a light-gray sandstone. No fossils can be found in any of the rocks, so that it is difficult to determine their age with certainty. We believe that the lower beds are carboniferous, and have received their red color from the sediments which were doubtless derived from the disintegration of the red sienitic rocks upon which they rest. It is also quite possible that a portion of the red beds are triassic, and also that the yellow, gray, and rusty sands and sandstones above, are Jurassic.

Lying above the supposed Jurassic and beneath the well-defined cretaceous, there is a large thickness of sandstone which I have called transition strata, because they occupy the position of the lower cretaceous, as shown on the Missouri River and in Middle Kansas. These beds are well developed and quite uniform in their lithological character all along the mountain sides from latitude 49° to the Arkansas, yet they have never yielded a single characteristic fossil that would determine their age. I have, therefore, called them provisionally lower cretaceous, or beds of transition from one great period of geological history to another, and the characters of the sediments which compose them justify the name.

Near our camp on the Big Laramie, which was about thirty-five miles southwest of Fort Sanders, and about fifteen miles above the foot of the hills, are some singular illustrations of the dynamics of geology. On the southwest side of the stream, and inclining eastward or southeastward, the entire series of red and variegated beds are shown in their order of succession one thousand five hundred to two thousand feet in height. At the foot of this escarpment is a low ridge of the red material, which is so grassed over that the connection with the sienitic nucleus cannot be seen. This covers a belt of sienite about two hundred yards wide and three to five miles long, the jagged masses of rock reaching a height of one thousand feet or more, and standing nearly vertical or dipping slightly to the southeast. Between the sienitic beds and the river are the two low ridges of cretaceous Nos. 2 and 3, which seems to have been lifted up with the sienite, but to have fallen back past a vertical position, so that they now incline from the sienite ridge, while on the opposite side the beds have a regular dip from the ridge. This peculiarity seems to be common in various localities, owing to the fact that the metamorphic beds which compose the central portion of all the mountains have suffered upheaval, prior to the deposition of the unchanged beds. Therefore, in the quiet elevation of the mountain ranges, the beds are merely lifted up in the direction of the dip of the older rocks on one side, while they are, as it were, pushed away from the opposite side, forming what may be called an abrupt or incomplete anticlinal.

On the opposite or south side of the river there is a gradual slope of two thousand feet above the bed of the stream, the strata inclining 5° until we reach the nucleus of another mountain range; so that we have here, as it were, two huge monoclinals. These monoclinals form local anticlinals, inasmuch as, in some places, all the beds incline for a short distance from a common axis.

On the north side of the river, and east for ten to twenty miles, the flanks of the mountain ranges are covered with the unchanged rocks, which give comparatively gentle grassy slopes, owing to the readiness with which they yield to atmospheric agencies. Through these slopes many little streams cut their way, forming huge cañons, which exhibit along their sides the series of beds in their order of succession.

From a point near the source, for twenty or thirty miles, the river flows through a synclinal valley, the conspicuous red beds dipping from either side. Along the valley of the river are marked deposits of drift, the result of glacial action; but the most beautiful feature is the well-defined terraces, about fifty feet high and smoothed off like a lawn. These terraces are covered with a considerable deposit of drift; but when they are cut through by streams the basis rocks are shown.

The scenery on either side of this valley is beautiful beyond description. On the west side are the snow-clad peaks of the Medicine Bow range in the distance, with numerous intervening lower ranges ascending like steps. The snowy mountains are mostly destitute of vegetation and are covered with eternal snow, but the lower mountain ridges are covered mostly with what may be called groves of pine. Indeed, the pine groves and grassy openings are so arranged and proportioned that the whole scene appears as if it might have been partially the work of art, and the traveler imagines himself in a sparsely-settled mountainous district instead of the unexplored Rocky Mountain region. These openings and grassy slopes will make excellent pasture grounds, for the grass is good, and they are watered with the finest of mountain streams and springs. I would again remark that the pine forests of these mountains must at some period be an object of earnest pursuit. Two years ago the mountain sides were full of tie-cutters, who cut and floated hundreds of thousands of ties down the mountain streams, fifty to one hundred miles, to the Union Pacific Railroad, whence they were transported by railroad to any desired point.

In the moist ravines of the mountain sides are patches of the aspen, *Populus tremuloides*, which, from its peculiar mode of growth, forms a striking feature in the landscape. It grows very thickly, seldom attaining a height of more than forty or fifty feet, and not more than twelve to eighteen inches in diameter. The body is very smooth and nearly white, and the top forms a rounded, cone-shaped mass of foliage. These aspen groves are the favorite resort of deer, elk, grouse, and all kinds of game.

On the east side, also, is the snow-clad range, which, in its southward extension, includes Long's Peak and numerous other peaks in the vicinity. On each side of these lofty ranges, which often rise above the limit of vegetation, are a number of successive lower ridges which descend like steps. There is such a wonderful uniformity in the structure of the mountains that a detailed description of a portion applies for the most part to all.

Our course along the Cherokee Trail was about southwest from the Big Laramie River, over ridge after ridge, and after traveling twenty-five miles we entered the North Park through some of the most beautiful scenery of that interesting region. From the summit of the high ridges on the north we look to the southward over a series of lofty cones or pyramids, as it were, all clothed with a dense growth of pine. The metamorphic rocks of which these mountains are composed, disintegrate so easily that the surface is covered with a deposit of loose material, as fine earth and fragments of rock. The hills have, therefore, been so smoothed down that it is difficult to see the bass rocks in continuous lines. We saw enough, however, to show us that red sienite in its various forms constitutes the principal rocks, while now and then a bed of hornblendic gneiss, white quartz or greenstone, occurs. All through the mountain region are small open areas, sometimes on the hills and sometimes in the lower grounds, forming meadow-like spots, which the various kinds of animals love to frequent, to feed on the abundant grass. The Old Cherokee Trail derives its name from the fact that a party of those Indians cut its way through the thick pines, about thirty years ago, with a train of three hundred wagons.

The traveling was difficult at this time, owing to the ruggedness of the surface and the obstruction from the fallen pines.

So far as I could ascertain, the trend of the upland mountain ridges of sienite is nearly east and west, and the dip nearly north. The North Park is oval or nearly quadrangular in shape, about fifty miles in extent from east to west, and thirty from north to south, occupying an area of about one thousand five hundred square miles. Viewed from one of the high mountains on its border it appears to be a vast depression which might once have formed the bed of a lake. Its surface is rather rugged, yet there are broad bottoms along the streams, especially the North Platte and its branches. Scarcely a tree is to be seen over the whole area, while the mountains which wall it in on every side are dotted with a dense growth of pine. The grass grows in the park quite luxuriantly, often yielding two tons of hay to the acre. Streams of the purest water flow through it, a few of them forming good-sized streams where they issue from the ground, and I am quite confident that this entire park would make an excellent grazing region for at least six or eight months of the year. Myriads of antelope were quietly feeding in this great pasture ground like flocks of sheep. The soil is very rich, but the seasons are too brief for the successful cultivation of any crops. Indeed, there is frost here nearly every night, and snow falls every month of the year.

As I have before stated, the park is surrounded with lofty ranges of mountains as by gigantic walls. On the north and east sides may be seen the snow-covered ranges rising far above all the rest, their summits touching the clouds. On the west side there is also a short snowy range. The snowy ranges on its east border have their north sides abrupt; the south sides are less so as seen from a distance, and the massive, rocky, lower hills appear inclining southward. All along the north side the hills incline southwestward, while the higher ranges are quite steep, and correspond in the apparent dip of the beds to the lofty snow-clad mountains on the east, which incline south or southwestward. The inclination of the metamorphic beds composing the higher ranges is from 60° to 80°. On the west side of the park long ridges seem to slope gradually down, so that they die out in the plain, forming a sort of *en echelon* arrangement. It is due to this fact that the area inclosed receives its oval shape.

The general trend of all the continuous mountain ranges is nearly northwest and southeast on all sides, but there are many local dips and variations from this direction.

I was much interested to know whether any of the unchanged rocks, which are so well developed in the Laramie Plain, occur in the North Park. I found that the entire series of red and variegated beds, including a portion of the cretaceous strata, were fully represented, all inclining from the flanks of the mountains and gradually assuming a horizontal position, or nearly so, toward the central portion of the park. The transition beds or lower cretaceous, form quite conspicuous ridges, inclining 19° to the southwest. They are composed of a very beautiful pudding stone of small rounded pebbles, most of them flint, cemented together with a silicious paste. On the north side are quite large areas covered with loose sand, which is blown about by the wind, resembling the Sand Hills on the Niobrara River. A close examination of the sand shows, that it is composed mostly of worn particles of quartz and feldspar. The surface contains little or no vegetation, presenting a peculiar barren appearance, the sand moving readily with the wind.

Hitherto it has been impossible to color on any geological map the geological formation of any part of this mountain region, and no information has ever been given in regard to the structure of the North Park. It will be impossible even now, with the imperfect topography of any of the maps, to color the geology in detail, but these explorations will enable a geologist to fix the outline of the formations in a general way with a good degree of accuracy.

During the summer of 1868 an excitement was created at Laramie City by the supposed discovery of rich placer mines far up in the mountains, near the Snowy ranges, to the southwest of the plains. A large party was formed at Fort Sanders, directed by Generals Gibbon and Potter of the United States Army, and accompanied by Professor James Hall of New York, to visit the region and ascertain the truth of the reports. The time was most favorable, in midsummer, when the mountain vegetation presents a spring aspect.

Camping with our wagons at the base of the main range of mountains, near the source of the Little Laramie, we prepared to ascend the mountains on horseback to the gold mines. We rode a distance of about ten miles before we came in view of the "diggings," and to reach them made an ascent of about two thousand feet above the bed of the creek. We were then between 10,000 and 11,000 feet above the sea, very near the elevation of perpetual snow, and where frost occurs every night of the year. On the summits of these lofty mountains are some most beautiful open spots, without a tree and covered with grass and flowers. After passing through dense pine forests for nearly ten miles we suddenly emerged into one of these park-like areas. Just in the edge of the forest which skirted it were banks of snow six feet deep, compact like a glacier, and within a few feet were multitudes of flowers, and even the common strawberry seemed to flourish. These mountains are full of little streams of the purest water, and for six months of the year good pasturage for stock could be found.

The gold is sought after in gulches, formed by the little streams that flow from the Medicine Bow and other snowy mountains, most of which empty into the North Platte. We labored for two days to discover the quartz seams, which we supposed to be the source of the stray lumps of gold, but the great thickness of superficial drift which covers all these mountains concealed them from our view. The gold, as far as known in this district, seems to be confined to the lower glacial drift. That valuable mines will be found in these mountains at no distant day seems very probable. The geological evidence is quite conclusive, and the mountains are a continuation northward of the same range in which the rich mines of Colorado are located.

Not only in the more lofty ranges, but also in the lower mountains, are large forests of pine timber, which will eventually become of great value to this country. Vast quantities of this pine in the form of railroad ties are floated down the various streams to the Union Pacific Railroad. One gentleman alone contracted for 550,000 ties, all of which he floated down the stream from the mountains along the southern side of the Laramie Plains. The Big and Little Laramie, Rock Creek, and Medicine Bow River, with their branches, here literally filled with ties at one time, and I was informed that in the season of high water they can be taken to the raliroad from the mountains, after being cut and placed in the water, at the rate of from one to three cents each. These are important facts, inasmuch as they show the ease with which these vast bodies of timber may be brought to the plains below and converted into lumber, should future settlement of the country demand it.

There are several species of pine trees and one spruce or balsam fir, *Abies Douglassi.* The latter is a beautiful and symmetrical tree, rising to the height of one hundred to one hundred and fifty feet, and as straight as an arrow. The ties that are made from this spruce are of the best quality.

We will now return to Fort Sanders, and continue on our westward way. From Fort Sanders to Cooper's Lake Station the distance is about twenty-eight miles. On our right hand we can see, with great distinctness, the Laramie Mountains as they flex around westward, preserving a remarkably symmetrical appearance. A heavy bed of limestone, which appears not to have suffered greatly from erosion, covers the flanks high up to the margins of the summit, and seems to have protected their rounded sloping form. Here and there may be seen a deep gorge cut through at right angles by some little stream, that has its source in a spring on the summit. Along the base of the mountains, on the east side of the road, patches of the brick-red beds are very abundant, giving a picturesque appearance to the view. After crossing the Big Laramie the surface is quite uniformly level or rolling, and covered with thick grass or sage. The country is underlaid with upper cretaceous rocks, and possibly in some places there may be small patches or remnants of tertiary beds. We seem to be gliding along over a nearly level, monotonous country, with scarcely anything to intercept the vision. Far to the westward the dim outlines of the Medicine Bow range can be seen, reminding us that we are walled in by lofty mountains. But the road is fine, and sometimes for long distances the track seems as straight as an air-line. These broad, grassy plains are not yet entirely destitute of their former inhabitants; flocks of antelope still feed on the rich nutritious grasses, but the buffalo, which once roamed here by thousands, have disappeared forever. No trace of them is now left but the old trails, which pass across the country in every direction, and the bleached skulls which are scattered here and there over the ground. These traces are fast passing away. The skulls are decaying rapidly, and this once peculiar feature of the landscape in the West will be lost. Two years ago I collected a large quantity of these bleached skulls and distributed them to several of our museums, in order to insure their preservation.

There is also a singular ethnological fact connected with these skulls. We shall observe that the greater part of them have the forehead broken in for a space of three or four inches in diameter. Whenever an Indian kills a buffalo he fractures the skull with his tomahawk and extracts the brains, which he devours in a raw state.

Indians or old trappers traveling through the enemy's country always fear to build a fire, lest the smoke attract the notice of the foe. The consequence is that they have contracted the habit of eating certain parts of an animal in an uncooked condition. I have estimated that six men may make a full meal from a buffalo without lighting a fire. The ribs on one side are taken out with a knife, and the concavity serves as a dish. The brains are taken out of the skull, and the marrow from the leg bones, and the two are chopped together in the rib-dish. The liver and lungs are eaten with a keen relish, also certain portions of the intestines, and the blood supplies an excellent and nutritious drink. Both Indian and buffalo have probably disappeared forever from these plains. Elk, black-tailed deer, red deer, mountain sheep, wolves, and the smaller animals are still quite abundant, especially in the valleys of the small streams, where they flow down through the mountains; Elk Mountain and Sheephead Mountain have always been noted localities for these animals.

The traveler will have his attention called to Carmichael's Cut, an excavation through the arenaceous clays and sandstones of the upper cretaceous deposit, which has become noted for the wonderful fossils found there. Baculites, Ammonites, Inocerami, and a great variety of marine shells, glistening with the iridescent hue of mother-of-pearl, are found in aggregated masses, as if this had been a portion of the cretaceous sea. Farther on, at Miser Station, these beautiful fossils occur again in the greatest abundance, and thousands of them have been gathered and carried away by curiosity-seekers. Near Medicine Bow the lower cretaceous clays prevail, and in the hills bordering the Medicine Bow Creek a large singularly tuberculated ammonite is found associated with a species of scaphites or boat-shaped shell, looking very much like a large worm coiled up, and hence its name, *S. Larvæformis.* These shells have received all sorts of names in the country, and the most wonderful tales are related of petrified snakes, &c.

All over this Rocky Mountain region, from the Arctic Circle to the Isthmus of Darien, these remarkable marine shells are found, and in some instances upon the summits of the loftiest ranges.

The valleys of the Upper Missouri and Yellowstone Rivers have already yielded nearly four hundred varieties of these sea-shells. We have, therefore, the most ample evidence that in past geological times the great ocean rolled all over the area now occupied by the mountain ranges.

After passing Cooper's Creek Station we come into the black clays of the lower cretaceous, and the appearance of the country becomes dreary and sterile in the extreme. The waters are alkaline, and there is no timber along the creeks except stinted willows, and very little grass or vegetation except chenopodiaceous shrubs, which are fond of this alkaline soil. As far as the eye can reach nothing can be seen but these somber, plastic clays. The surface also presents the characteristic monotonous appearance which is common wherever these clays prevail. Six miles before reaching Como we come to an interesting quarry of sandstone, from which the materials for the construction of the extensive railroad buildings at Laramie City and Cheyenne are obtained. The rock is gray, coarse, and friable, and one would suppose not durable enough for such important structures, but it is easily wrought into any determinate form. This is a locality to which I call the special attention of the geologist as one in which there is an interesting problem to work out, viz: What is the exact position of this sandstone in the geological series? It is filled with fragments of vegetable impressions, with sometimes quite distinct deciduous leaves, much like those already noticed in Chapter II as occurring at Blackbird Hill, on the Missouri River. The leaves of the willow and poplar are quite distinct, reminding one of those growing along our little streams at the present day, and yet they are all of extinct species. These sandstones are local and seem to have been deposited over a small area, inasmuch as they occur nowhere else on the plains, so far as I have observed.

The black shales filled with remains of fishes and marine shells occur above and below the sandstones, showing very clearly that they are of lower cretaceous age. Still it would be a matter of interest to attempt the construction of the physical conditions which were necessary in those old cretaceous times, myriads of ages ago, for the ocean waters to deposit such an accumulation of sandy material in this locality. The scenery is somewhat changed also; the little stream which cuts through the rocks flows through vertical walls of the sandstone one hundred to two hundred feet high.

Farther on toward Como we see on our right hand the brick-red beds which are so common along the slopes of the first range. At Como Station the road runs through a curious anticlinal valley, the strata inclining in opposite directions about northeast and southwest. The southwest side displays the most complete series of the beds They are composed for the most part of alternate layers of sands and some harder beds of sandstone, but there are a few of these beds of marl, or limestone, in which are found great quantities of fossil shells, *Ostrea Pentacrinus asteriscus* and *Belemnites densus.* The oyster is a very small one; the star-fish is very beautiful but imperfect; and the *Belemnite* or ancient cuttle-fish is more abundant and more characteristic than the others. They are all of well-known Jurassic types. All around the shores of the pretty little lake thousands of these sharp-pointed *Belemnites* have been gathered and given to travelers. These fossils are very abundant in some parts of Europe, where they are called "Ladies' Fingers," from their long, slender, symmetrical shape. These fragments are all that remain of an animal that was probably quite large and complicated in its structure, much like the cuttle-fish of our present seas. It undoubtedly had the power to secrete a black liquid, a sort of ink or sepia, which it could emit at pleasure, and thus provide a place of concealment when pursued by foes.

There are other attractions here, of which the traveler will be informed long before he reaches the locality. The "fish with legs" are the only inhabitants of the lake, and numbers of persons make it a business to catch and sell them to travelers. During the summer season they congregate in great numbers in the shallow water among the weeds and grass near the shore, and can be easily caught, but in cold weather they retire to the deeper portions of the lake and are not seen again until spring. These little animals are possessed of gills, and were it not for the legs, would most nearly resemble a miniature cat-fish. But when warm weather comes, a form closely resembling them, but entirely destitute of gills, may be seen in the water swimming, or creeping clumsily about on land. Sometimes they travel long distances and are found in towns, near springs or wet places, usually one at a time, while those with gills are never seen except in the alkaline lakes which are so common all over the West. Professor O. C. Marsh, of Yale College, Connecticut, an eminent naturalist, while on an excursion along the line of the Union Pacific Railroad two years ago, observed a number of the gilled forms or *Siredons*, and taking them to New Haven, watched their remarkable transformation into the more mature condition without gills. These animals belong to the family of *Salamanders*, a group allied to the frogs, and the first form bears about the same relation to the last that the tadpole does to the mature frog. Professor Marsh's very interesting and detailed account of these singular animals can be found in the "American Journal of Science" for November, 1868, and from his article I have taken the following extracts:

"The first indications of any change were observed in one of the smaller specimens, about six inches in length; and the metamorphosis had apparently commenced during the journey from Lake Como to New Haven, which lasted about a week. Small round spots of dark brown were first noticed on the sides of the tail, and the color of the entire animal gradually assumed a darker hue. The broad thin membrane along the back, and above and below the tail, gradually began to diminish by absorption; the external branchial appendages soon became similarly affected, especially at the ends, and the animal came more frequently to the surface of the water for air. As the change went on, the dark spots increased in number and size, and gradually extended over the whole upper part of the body. The membrane on the back and tail entirely disappeared, leaving in its place in the dorsal region a sharp groove. The branchiæ also continued to diminish, and at the same time the internal branchial arches began to be absorbed, and shortly after the openings on the neck closed up. In the mean time the head became more rounded above, and more oval in outline, the muzzle narrower and more pointed, and the eyes more convex and prominent. The body also decreased in bulk, and the costal grooves became more distinct. The thin external skin was shed, and the secretion of mucus from the surface sensibly diminished. During these changes the animal showed an increasing desire to leave the water, often remaining for some time with its external nostrils above the surface, and occasionally making violent struggles to escape. Aided by a heavy rain at night it at last succeeded, and thus put an end to further observations, just at a time when it had lost the generic characters of *Siredon*, and become a true *Amblystoma*, two forms of batrachians usually regarded hitherto as belonging to distinct families."

Fortunately, a few days later, several other specimens of various sizes began, nearly at the same time, to show unmistakable indications of a similar transformation, and this afforded an opportunity of noting the successive phases of the change more fully, as well as observing the physical conditions which seemed to promote or retard it. Two of the specimens were placed in a glass jar, and left in a strong light, and five others were kept in a cooler place in the shade, the temperature of the two, however, differing but a few degrees. At the end of three weeks those in the glass vessel had apparently completed their metamorphosis, while of the others less favorably situated three only were partially altered, and at the present time, or nearly three weeks later, they still retain tubercular remnants of the external branchiæ, although in most other respects the change appears to be complete. The two remaining specimens, however, which had throughout been kept with the three last, showed no distinct signs of changing, although the probability of their doing so, and the importance of retaining some tangible evidence of the original condition, led to the transfer of one of them to a jar of alcohol after the first week, a precaution, as the result showed, quite unnecessary in the case of the other, which at the time of writing (October 5) still remains a typical *Siredon*, with no alterations more important than a single appearance in a new epidermis.

Similar observations had already been made by a celebrated French naturalist, Professor Dumeril, on an allied species, found on the tablelands of Mexico; and it was a matter of no small interest to Professor Marsh to ascertain whether this species would undergo a similar change when placed under different physical conditions, hence these creatures were watched with great care.

Among the more important changes which occurred during the metamorphosis may be mentioned the decrease in the size of the entire body, which was very marked, a perceptible increase in the distinctness of the costal grooves corresponding to the vertebræ, and the gradual ossification of the carpus and tarsus. The feet also became less palmate, and the toes less depressed. During the transformation, moreover, and especially after its completion, all the specimens shed the thin, transparent epidermis, some of them very frequently; one, indeed, which had been kept in a strong light, lost this covering three times in the ten days immediately following the metamorphosis.

The change in the habits of the *Siredon* in passing into the *Amblystoma* state was scarcely less marked than the alteration in its physical characters. As soon as the absorption of the external branchiæ commenced, the animal came more frequently to the top of the water and took a mouthful of air; and not long afterwards would occasionally float for some time at an angle of about 45°, with the external nostrils above the surface. Frequent efforts to leave the water soon followed, and an opportunity of so doing was in most instances speedily improved, and the change then seemed to progress more rapidly. One or two specimens, however, showed for some time, especially in cool weather, much less inclination to desert their native element, apparently suffering little or no inconvenience from remaining under water, if allowed to come to the surface about once in five minutes. The pugnacious propensities of the *Siredons* which at first led to occasional assaults on one another, appeared to diminish as the change progressed, and the more sluggish nature of *salamanders* at last predominated; although the altered forms at times showed no little celerity of movement, and when irritated, especially when held by the tail, would often turn and snap at the hand with a rapidity that would have done no discredit to a reptile of much higher organization.

The effect on the metamorphosis of a variation in light and temperature has already been alluded to. During a succession of very warm days, about the first of September, the change progressed with great rapidity, but it apparently ceased, or made very slight progress, in the cool week that followed. While, moreover, the two specimens most favored in regard to light and warmth passed apparently through the entire transformation in about twenty days, those which commenced at the same time, but were less favorably situated, required at least twice that time for its completion. The only living specimen still remaining unchanged has twice shown slight indications of an approaching metamorphosis, but with the exception of some spots, these have apparently soon disappeared after a transfer to a dark and cooler place.

As we pass on westward we come into the eastern border of the great coal fields of the Rocky Mountains, and inasmuch as they are of vast importance to this great thoroughfare, as well as to the country, I will make them the subject of the next chapter.

CHAPTER XI.

WESTWARD TO BEAR RIVER.

Soon after passing Medicine Bow Station, the dark, somber appearance of the surface of the country ceases, and the more cheerful aspect produced by the overlapping of the tertiary beds is seen. We move on rapidly through inclined ridges of sandstone and shaly clays, dipping westward from 30° to 50°. Here we begin to discover indications of coal in the black bands of carbonaceous clay that crop out on either side of the road. But the most marked development of the coal beds will be observed at Carbon Station, about one hundred miles west of Laramie. The first openings were made about three hundred yards from the railroad track, where a bed of coal was discovered nine feet in thickness. The demand for the coal was such that it was thought advisable by the company to sink a shaft close by the track, and now the coal is taken out in large quantities daily for the use of locomotives. A thriving little town has been built up here by the coal trade alone.

The coal which is taken out of this mine is of the best quality of the tertiary brown kind, and is very compact and pure. It is not as hard as anthracite, but the miners informed me that it was more difficult to work than the bituminous coals of Pennsylvania. The engineers speak in high terms of it as fuel for locomotive use.

Just over the coal is an earthy bed of what the miners call "slate," which breaks into slabs, showing a woody fiber, and much of it looks like charred wood or soft charcoal. A little higher up we find thin layers composed almost entirely of fragments of deciduous leaves, and above these come various kinds of clays and sands. Beneath the coal there are indurated clays and rocky strata, in which occur thousands of impressions of leaves much like those of our common forest trees, but belonging to species long since extinct. They belong, however, to genera such as *Populus*, *Platanus*, *Tilia*, with many others, most perfectly preserved, and all plainly pointing to a period far back in the geological past when these vast, treeless regions of the present time were covered with dense forests, surpassing even those now growing in Ohio and Kentucky. Some of the layers of rock, two to four inches in thickness, are almost entirely made up of these leaves, and the condition in which they have been preserved shows that they could not have been transported any distance, but must have fallen from trees that grew in the vicinity. Indeed, there is no doubt, for myriads of ages in the past, gigantic poplars, sycamores, lindens, oaks and others spread their broad branches over the shores of some little streams or lakes, and shed their foliage in the shallow waters in the same manner as they do at the present day. In the autumn I have seen the sandy bottoms of the little streams that flow into the Missouri and Yellowstone Rivers filled with the leaves of the cottonwood and elm in a perfect state of preservation, and had the conditions been favorable for compacting these sediments into rocky layers, the geologist might have split them open with his hammer, and revealed the leaf impressions as perfectly preserved in every part as if they had been carefully pressed in a lady's herbarium. The traveler will find it profitable and instructive to remain at this locality a day.

The coal is not confined to the neighborhood of the road. It crops out in many localities for twenty or thirty miles on either side, so that we see there is an abundant supply of fuel stored away for future use beneath this apparently barren surface. When we reflect that nearly all the wood or timber that is used along the line of the road has to be transported a distance of twenty to forty miles, and that even this scant supply will be exhausted within a few years, we shall at once arrive at the conclusion that the future success of this great thoroughfare is entirely dependent on the supply of mineral fuel, and that its importance for all time to come cannot be too highly estimated.

The coal formations extend along the line of the road to St. Mary's Station, a distance of twenty-five miles west of Carbon; from thence to Rawlins's Springs, about thirty miles, the road passes over strata which are mostly of cretaceous age. To the geologist this entire region is one of great interest. Even up to the present time it is invested with much obscurity. Probably no rocks older than cretaceous or tertiary occur; but the beds are so complicated by the forces that have elevated the neighboring mountain ranges that it is difficult to unravel their relations.

Soon after leaving Carbon we pass through several cuts which show the strata, sometimes inclining nearly west, and soon again in the opposite direction. We seem to be continually passing across a series of anticlinal and synclinal axes. Just before reaching the North Platte River we pass along the valley of one of the most remarkable anticlinals in the West. On either side of the road the rusty-gray sands and sandstones incline at an angle of 10° to 15°. The strata rise like walls on both sides to the height of seven hundred or eight hundred feet in graduated ridges or steps. I have been informed that thin beds of coal have been discovered within a few miles of Fort Steele; if this be so, they must occur high up on the summits of these ridges. Near the bridge over the North Platte the black, plastic clays of the lower cretaceous are distinctly seen, but following up the exposed edges of the inclined ridges we find an oyster and an *Inoceramus* which are peculiar to the upper cretaceous beds. Passing up still higher, we shall discover thin layers made up wholly of a small species of oyster, which seems to be characteristic of what I regard as transition or beds of passage between the strictly marine sediments of the cretaceous era, and the brackish and the fresh water which characterize the tertiary period.

We can see here a marked instance of a valley of erosion, or a long natural opening, as if prepared in ages past for the passage of the road. We can reflect with what ease comparatively it has been constructed across what would seem to be an impassable country, by following the water-courses and their valleys of erosion, admiring the energy and consummate skill of the engineers who first located the road through this wild and rugged region.

We have not alluded to the scenery in this vicinity from the fact that to the ordinary traveler there is little that is attractive. To most persons the whole country would appear like a barren waste. But if we look far away southward toward the sources of the North Platte in the North Park, we shall see some lofty ranges of mountains with peaks that loom up in solitary grandeur. Elk Mountain is a noted landmark, and seems to rise out of the plain as if it were an isolated peak. It is, however, a portion of the Medicine Bow range, partially cut off from the northern end. It is surrounded by rolling prairie, which is covered the greater portion of the year with splendid grass. Hence all the river valleys in this portion of the mountains have been noted places for game of all kinds, as elk, deer, mountain sheep, &c. Fabulous stories are also told of the mines of gold and silver which have been discovered. As yet the geology is little known. The sides of these mountains are covered with dense forests of pine, spruce, and hemlock; and during the construction of the railroad thousands of ties were floated down the branches of the North Platte into the main stream and thence taken to their destination. The little streams that flow from the mountains have in many places quite broad valleys, which afford an abundance of hay and pasturage for all kinds of animals, wild and domestic. The wild animals often descend into the beautiful grassy bottoms to feed in large herds, and at the least approach of danger retire to the almost inaccessible ravines and gorges of the mountains. The big-horn or mountain sheep may often be seen in flocks, peering from some mountain peak upon the traveler below. Early in the morning these animals descend into the valleys to crop the moist grass, but during the greater portion of the day they will be found, if discovered at all, upon the most precipitous crags and ridges of the mountains. The little streams are full of fine trout, which are easily caught, they not having learned as yet the cunning arts of self-protection, like their eastern relatives. These ravines and gorges afford most excellent shelter, both for Indians and animals, during the cold season of winter. The close proximity of this delightful region to the railroad must make it a desirable place of resort for sportsmen during the summer.

There is another interesting feature connected with the North Platte and its tributaries, as well as with most of the mountain streams, to which I would call the attention of the inquiring traveler; and that is, the abundant signs of the existence of that most sagacious animal, the beaver. These mountain streams seem to abound with them at the present time, and their dams are very numerous, not unfrequently producing a rise of the water, three to five feet. Extensive dams and ponds are caused by these industrious animals, and sometimes quite large areas in the valleys are overflowed, rendering the crossing difficult and dangerous. They sometimes strip off the usual fringe of cottonwood and willows along the streams so completely that they are obliged to emigrate to some other locality to secure food and materials to repair their dams.

Not far from Fort Steele may be seen at this time cottonwood trees, eighteen and twenty inches in diameter, which have been cut down by them, and I have seen stumps in the valley of the Yellowstone thirty inches in diameter. Their fur is of so little value at the present time that they are not much sought for by trappers or Indians.

From St. Mary's to Rawlings' Springs, a distance of about thirty miles, the railroad passes over rocks of cretaceous age. No coal beds need be sought for in the immediate vicinity of the road, although it is quite possible that on the north side of the road isolated patches of tertiary containing coal may be found. The railroad from a point about eight miles east of Benton to Rawlings' Springs passes through one of the most beautiful anticlinal valleys I have seen in the West. On either side the rusty-gray sands and sandstones dip away from the road at an angle of 10° to 15°. This anticlinal valley is most marked near Fort Steele at the crossing of the North Platte.

About five miles east of Fort Steele I made a careful examination of a railroad cut through a ridge of upheaval, which inclined about south or a little east of south. We have exposed here, commencing at the bottom—

1. Gray, fine-grained sandstone, rather massive and good for building purposes, and easily worked, eighty feet thick—dip 25°.
2. A seam, two feet thick, of irregular, black, indurated slaty clay, with layers of gypsum all through it, then two feet of arenaceous clay.
3. Ten feet of rusty-gray, compact sandstone.
4. Eight feet of clay and hard, arenaceous layers, very dark in color, passing up into harder layers, which split into thin laminæ, the surfaces of which are covered with bits of vegetable matter.
5. About fifty feet of rusty, yellowish-gray sandstone. All these sandstones contain bits of vegetable matter scattered through them.
6. One hundred to one hundred and fifty feet of steel-brown indurated clay with some iron concretions. The clay is mostly nodular in form.
7. A dark-brown arenaceous mud rock, quite hard, thirty feet.

From bed five, I obtained numerous species of marine shells, among them a species of *Ostrea* and *Inoceramus* in great numbers. The upper surfaces of the hard clay layers appeared as though crowded with impressions of sea-weeds or mud markings. In another railroad cutting about four miles east of Rawlings' Springs I obtained the same *Inoceramus* and a large species of Ammonite. These fossils are important in establishing the age of these rocks. Fort Steele is located on the north side of the railroad, and presents a pleasant and quite pretty appearance to the traveler. I intended to make a more careful examination of the geological features of this interesting region, but failed for want of time. The officers at this post have always manifested great interest in having the scientific as well as the practical resources of the surrounding country examined, and their favors to my party have been very generous. I take great pleasure in thanking the commandant, Colonel L. A. Bradley, of the Ninth Infantry, also Captain James Jackson, quartermaster, for favors extended to me in time of need.

In the channel of the North Platte, near Fort Steele, the black clays of the upper cretaceous are most distinctly shown, then gradually pass up into the series of sandstones and clays that form the lofty walls or ridges on the north side of the railroad. We can count from six to ten beds of yellowish-brown sandstone, with inclining beds of arenaceous clay. In the lower portions the *Inoceramus* or Baculite is rarely found, the arenaceous character of the sediments seeming to have been unfavorable to abundant animal life. Higher up a seam of oyster-shells of an unknown species occurs. They are probably what I have regarded as the transition or beds of passage from the cretaceous to the tertiary. They are even better displayed from the west side of Bridger's Pass to Elk Mountain, along the old overland stage road. Beds of coal are known to crop out among the distant hills on either side. There is undoubtedly a mingling of the two formations to such an extent that a careful detailed survey of this district is necessary to clear up all the obscure points. It is probable, however, that the North Platte cuts down into the cretaceous beds most of the way, and possibly entirely, from the mountains to the south, far north of the railroad.

Fig. 11 may be introduced in this connection to illustrate the style of the erosion of the lower tertiary coal formations in the Laramie plain.

The view is taken from the tertiary hills bordering the Missouri River, near the mouth of the Yellowstone, but is typical of the "bad lands" all over the West where this formation prevails. The little streams formed from the drainage of the hills cut deep gorges into the soft superficial deposits at their base, and frequently produce great obstructions to trains of wagons.

Fig. 11.

As we move on west of Fort Steele, we can see on the north side the outcropping beds of sandstone. About three miles west of the North Platte this ridge gradually bends off toward the northwest. The cretaceous clays of No. 4 are weathered so that the surface has a smoothly rounded appearance, and the anticlinal beds expand out into a broad plain. The anticlinal extends a little east of south toward Pass Creek. The erosive forces seem to have come from the southeast, between the detached fragments of the Medicine Bow range, and extended across the country toward the northwest. West of Fort Steele the road passes along an anticlinal valley for about two miles; it then enters a monoclinal valley and continues for six or eight miles; then it cuts through cretaceous ridges which incline northeast. Before reaching Rawlings's Springs the red beds are exposed on the north side of the road about a mile distant. These anticlinals seem to pass across the intervening country, connecting the ranges of mountains south with those far to the north. It is only here and there that rocks older than the cretaceous or tertiary are exposed by them, until we come into the vicinity of some important range. But at Rawlings' Springs all the formations are exposed over a restricted area, from the granites to the cretaceous inclusive. The elevating forces were exerted more powerfully here than at any other point along the railroad from Laramie Station to the Wasatch Mountains. To the south of the road are variegated gray, brown, and reddish siliceous rocks dipping 5° to 10° southwest. A very hard, bluish limestone resting upon them I have no doubt is carboniferous, although I was unable to find any fossils in this region. North of the road ridges of upheaval stretch away toward the northwest, and attain a height of twelve hundred to fifteen hundred feet above the road. On careful examination the red syenite may be found exposed in a number of places, and gives us the opportunity of studying the relation which the unchanged rocks sustain to the metamorphic. The syenite beds dip 70° about southeast, the unchanged beds resting upon them in nearly a horizontal position. The layers immediately on the syenite are a beautiful pudding-stone of rounded quartz pebbles and feldspar, and above it layers of fine siliceous rock, with thin intercalations of clay, the whole having the position and appearance of Potsdam sandstone. I am inclined to believe that we have here Lower Silurian representatives. In all cases these rocks repose on the upturned edges of the syenite, sometimes nearly horizontal; again inclining 3° to 10°. In one or two places these Lower Silurian beds are lifted a thousand feet or more into the air, still maintaining a nearly horizontal position. On the mountain sides the beds are broken off so as to incline 50°, 60°, up to nearly 90°.

These siliceous rocks, covered with ripple marks, &c., afford excellent building stone, and are much used by the railroad company. They reach a thickness of five hundred to eight hundred feet. Upon them rests the blue limestone, thirty to forty feet thick; then variegated sandstones; and the red beds in the distance.

From the tops of these ridges one can see numbers of both synclinal and monoclinal valleys. There is one monoclinal valley, three to five miles wide, which stretches far into the northwest, a smooth and level grassy prairie. All these ridges have suffered great erosion, and the Silurian beds are planed and grooved even to a greater extent than the more recent beds. Everywhere the evidences of erosion during the drift period are on a gigantic scale.

A fine sulphur spring from under the bed of blue limestone gives name to the station. The water is clear and possesses excellent medicinal properties.

Some very interesting specimens of native copper have been found in this ridge, which at one time produced no small degree of excitement among the inhabitants. The copper ore was found, on more careful investigation, to be of no special economic value. It seems to occur as a sort of chemical precipitate in the reddish triassic quartzite near the summit of the ridge; sometimes it is diffused through the rock in green streaks in the form of green carbonate; sometimes coating large masses of calcspar; there are also very pretty dendritic impressions. Near the copper mines are some heavy beds of red oxide of iron, which must at some period become of great value to the country. The beds are four to six feet thick, and though they appear to be local, yet a great amount of ore could be taken out at comparatively small cost.

It is an interesting fact that, although we are continually traveling across what is usually regarded as the summit of the great Rocky Mountain range, six thousand to seven thousand feet above tide-water, yet this is the only locality along the road, between the Laramie Mountains and the Wasatch Range, in Weber Valley, where we meet with rocks older than Jurassic, and, except for a few miles near Lake Como, none older than cretaceous. Rocks of ancient date seem to be the exception, while those of quite modern age, geologically speaking, prevail.

Leaving Rawlings' Springs Station, the road passes through an anticlinal opening in the ridge, the south side inclining southeast 10° to 12°. The lowest beds are yellowish-gray quartzose sandstones, overlaid by carboniferous limestones. Still farther, south of the road, may be seen the rounded hills composed of the cretaceous and tertiary beds, but the intermediate formations, Jurassic and triassic, which are exposed on the north side, are concealed. Perhaps the best example of an anticlinal is seen soon after passing through the opening in the north side of the road. The valley trends a little west of north, or northwest. It does not show as distinctly on the north side of the road, with the exception of the fragment of a ridge which is conspicuous on the south side of the opening. Very soon the coal beds of the lower eocene appear on either side, inclining at a moderate angle, at first 15°. On the north side there is a plain, synclinal valley, extending off to the southwest. Passing across this anticlinal, we come out into an expansive, valley-like plain, with a long cretaceous ridge extending off to the southeast, while on the north side there is a low ridge of sandstone, with the strata again inclining to the northeast and trending to the northwest, thus forming an open sage plain. The formations on the north side are mainly the coal-bearing strata, with cretaceous clays cropping out at the base. On the south side the cretaceous beds seem to extend off to the southward as far as the eye can reach. In the distance the ridges which form the high hills near Bridger's Pass are distinctly visible, so that it is easy to connect our south belt of exploration with the middle one. It becomes still easier west of Separation, where the beds of the Washakie group are nearly or quite horizontal, and extend undisturbed across the country for nearly one hundred miles, from the Seminole and Sweetwater ranges on the north to the high hills of Bridger's Pass and the ranges to the southwest. The lower eocene, or coal beds, seem to dip from the mountains to the southward, if we glance across the country south of the road; and gradually to the north of the road they flex around so as to incline from the Seminole and Sweetwater Mountains. As usual, the lower tertiary beds are quite variegated in color—yellow, rusty-yellow, rusty-brown, and drab—presenting an exceedingly uncomely look. In the distance to the north the Seminole range can be seen quite clearly, with a trend about northwest and southeast.

Near Separation, about ten miles west of Rawlings' Springs, a coal bed eleven feet thick has been opened, probably the same as the one opened at Carbon, and near Rock and Cooper Creek. The dip is nearly west about 10°. The opening being at the summit of the hill, all the coal will have to be drawn up a slope, and the difficulties of drainage will be greatly increased. The coal is of excellent quality. Above and below the coal is the usual drab indurated clay. Below the clay is a bed of gray ferruginous sandstone.

On the summits of the hills in the vicinity are layers of fine-grained siliceous rocks with arenaceous concretions, some of them containing impressions of deciduous leaves.

The tertiary beds lie in ridges running across the country. The beds are uplifted in every direction. A more desolate region I have not seen in the West. Nothing seems to grow but sage bushes, and in some of the valleys they grow very large. All over the surface of the hills and in the plains are great quantities of water-worn pebbles. Many of these valleys were scooped out by an amount of waters far in excess of any known at the present day in this region. Some of the widest and deepest do not now contain any running stream.

The layers of fine-grained sandstone on the hills in this vicinity contain more or less impressions of leaves, like *Populus* and *Platanus*, in a good state of preservation.

West of Separation the dip of the tertiary beds diminishes. Before reaching Creston, about thirteen miles west of Separation, they lie nearly horizontal, and all the surrounding country presents more the appearance of a plain. At that station the Union Pacific Railroad Company have unk a well one hundred feet or more deep. At a depth of eighty-three feet, the workmen passed through four feet of excellent coal and four feet of coaly shale. The coal was of about the same quality as that near Separation, probably from the same bed. If so, coal at a depth of about eighty feet must underlie an area of at least one hundred square miles. In this well, beds of bluish, arenaceous clay were passed through first, then black clay, with carbonaceous matter throughout. Just over the coal was fine, bluish, indurated clay, with very distinct impressions of leaves, among which the most abundant were *Populus* and *Platanus.* The railroad cuts and the valleys themselves show very distinctly the character of the intermediate softer beds. The erosion has been so great in this country, and all hills and cañons are so covered with debris, that it is almost impossible to obtain a clear idea of the color and composition of the intermediate softer beds. The harder sandstones, &c., project from the surface, and are accessible to the eye without much excavation. Marine and fresh-water tertiary formations occupy the whole country along the line of the railroad to Quaking Asp Summit, west of Fort Bridger, and also to Salt Lake to a greater or less extent.

From Creston to Bitter Creek Station, a distance of forty-five miles, the beds are mostly fresh-water, and hold a nearly horizontal position. West of Bitter Creek we come again upon marine tertiaries, dipping 3° to 6° nearly east. We have, therefore, between Rawlings' Springs and Green River, a sort of synclinal basin, the marine tertiary dipping west about 10° on the east side, and the same marine beds inclining east 3° to 6° on the west side; while at Table Rock, Red Desert, and Washakie, a considerable thickness of purely fresh-water beds are filled with fresh-water shells *Unio Washakeei*, *Goniobasis Simpsoni*, and *Viviparus.*

Table Rock is a square butte lifting itself about four hundred feet above the level of the road, composed of the beds of a sandstone which in many instances is little more than an aggregation of fresh-water shells.

After leaving Bitter Creek Station the hills approach nearer to the road, and show the characteristic features of the marine tertiary again. Seams of coal appear in many places, while yellow arenaceous marls, light-gray sand with indurated clay beds, and more or less thick layers of sandstone occur. The dip varies from 3° to 6° east or nearly east.

At Black Butte Station, on Bitter Creek, about fifteen miles west of Bitter Creek Station, there is a heavy bed of yellow ferruginous sandstone, irregular in its thickness and in part concretionary, and full of rusty concretions of sandstones of every size, from an inch to several feet in diameter, mostly spherical, and when broken revealing large cavities filled with oxide of iron loam. This sandstone, one hundred and fifty to two hundred feet in thickness, forms nearly vertical bluffs, and is worn by atmospheric agencies into the most fantastic shapes. Above it are sands, clays, sandstones of every texture, and coal beds, one of which, near the summit of the hills, has been burned, baking and melting the superincumbent beds. I found in several layers the greatest abundance of deciduous leaves, and among them a fine palm leaf, probably the same species which occurs in the coal beds on the Upper Missouri, named by Dr. Newberry, *Sabal Campbelli.* There is also a thin seam near one of the coal beds made up of a small species of *Ostrea.*

The railroad passes down the Bitter Creek Valley, which from its channel through the tertiary beds, and on each side high walls can be seen inclining at moderate angles. As we pass down the valley toward Green River, the inclination brings to view lower and lower beds. These are all plainly marine tertiaries, while an abundance of impressions of plants are found everywhere. No strictly fresh-water shells occur, but seams of *Ostrea* of various species.

In the final report, some detailed sections of these tertiary beds will be given. Yet I am convinced that local sections are not very important. The character is so changeable that two sections taken ten miles apart would not be identical, and in some cases not even very similar. The more recent the age of formations the less persistent seem to be their lithological characters over extended areas.

From Black Buttes to Point of Rocks the dip is southeast. About five miles west the principal bed of gray-brown sandstone rises to the surface. The railroad runs through what I have termed a monoclinal valley, that is, an interval between two upheaved ridges inclining in the same direction, the high outcropping hills on the north side, and the sloping portion on the other. The principal coal beds lie above the massive bed of sandstone, which forms a line of separation between the clays above, which are full of beds of coal, and the alternate beds of sandstone and clay beneath, in which there are few seams of coal.

The tendency of this sandstone to weather into curious forms and cavities has given peculiar names to localities, as "Hermit's Grotto," "Caves of the Sand," "Water-washed Caves of the Fairies," all of which exhibit most singular, rounded cavities worn out of the sandstone, sometimes extending into the bluff walls several feet. We may suppose that most of these cavities originally contained a spherical concretion which first determined their present rounded shape, and that the long-continued action of the wind and storms has enlarged them to their present dimensions. Perhaps, also, the trickling of water, or the process of freezing and thawing, may have performed a part in disintegrating the particles of sand. Here, too, we find preserved in the rocks the greatest abundance of deciduous leaves of the poplar, ash, elm, maple, &c., and among them some species which are found in the coal formations on the Upper Missouri. Among the fossil plants found is a species of fan-palm, which, at the time it grew here, displayed a leaf of enormous dimensions, sometimes having a spread of ten or twelve feet. These gigantic palms seem to have formed a conspicuous feature among the trees of these ancient forests.

At almost every station, from Bitter Creek to Rock Springs, coal mines are opened, and an abundant supply for railroad purposes can be easily obtained. At one locality, near Point of Rocks, five beds were opened in the same bluff, within a vertical height of eighty feet. These beds are respectively five, one, four, three, and six and a half feet in thickness. Near the summit of the hill, just over the coal, is a seam of oyster shells six inches in thickness. The oyster is of an extinct and undescribed species, about the size of our common edible one.

There are also in this range of hills extensive beds of hard, tabular layers of rock, which would make excellent flagging-stones. On the surface are fine illustrations of wave and ripple markings, and at one locality impressions which appear like the tracks of a mule on the soft bottom ground. There are others that might be attributed to a huge bird, and others to some four-toed pachyderm. Scattered all through the coal strata are seams and concretionary masses of brown iron ore, sometimes local and sometimes persistent over extended areas; it occurs mostly in a nodular form, and if the coal proves to possess sufficient heating power to smelt it, the ore must become eventually of immense economic value. There are also numerous chalybeate and sulphur springs in the vicinity.

About ten miles east of Salt Wells Station the high hills or bluffs on either side disappear, and it is plain that we are passing across an anticlinal valley in which only the yielding clays of the upper cretaceous period are seen. These clays have permitted the surface to be so rounded off that a distinct anticlinal valley can be seen extending across the country northeast and southwest. This valley is about six miles wide. Then the lower tertiary beds arise to the surface with a reversed dip and gradually pass up through a series of sandstones, clays, and arenaceous clays to the Green River shales. At Rock Springs the Wyoming Coal Company, under the direction of Mr. Thomas Wardell, an experienced coal miner, has opened a very valuable coal bed, which is now furnishing large supplies of fuel to the railroad.

Very soon after leaving Rock Springs Station the Green River Group is seen on the bluff hills on either side of the road to the entrance of Bitter Creek into Green River. In the Green River Valley are seen remarkable sections of strata. I have called this group the Green River shales, because it is composed of thin layers, varying in thickness from that of a knife-blade to several inches. The rocks all have a grayish-buff color on exposure, sometimes with bands of dark brown. These darker bands are saturated with an oily substance, which causes them to ignite readily. At one time this material was used as a fuel in stoves, and burned well, giving off a good supply of heat; but it was found that the bulk of earthy matter, after the combustible portion was burned out, was as great as the original mass, and rendered it too inconvenient. One of the cuts along the railroad passes through a layer of the cream-colored chalky limestone. There were one or two beds of this petroleum earth.

During the progress of the excavations the workmen built a fire by the side of one of the walls, and this oily earth ignited and burned for several days, giving light to the workmen by night, and filling the valley with a dense smoke by day. The best display of the Green River shales is near the station on the railroad. At the base of the bluffs we have thin layers of arenaceous clay, with laminated sandstone, with mud markings and other indications of shallow water or mud flats; color ashen brown, 100 feet. Above, lighter-colored layers with alternations of a greenish layer, fine white sand, the whole weathering a light gray. As we pass up we find a large increase of clay, and some lime, with now and then a thin layer of pebbles or small nodules. The layers vary from the thickness of a knife-blade to twelve inches, split easily and regularly. There are also local beds, four to ten feet thick, of porous limestone, which have the appearance of having been deposited from springs during the tertiary period. There are also seams of very fine limestone that are quite black, so thoroughly is the rock saturated with petroleum. The combustible shales vary in thickness, from two to several feet. Near the summit of the hill, under the yellow calcareous sandstone, there are fifty feet of the shales that contain more or less of the oily material. The hills all around are capped with a deep rusty-yellow calcareous sandstone, which weathers into the peculiar castellated forms which have given so much celebrity to the scenery in this region. The different shades of color in the thin layers give to the vertical walls a distinct banded appearance.

About two miles west of the station there is an excavation which has been called the Petrified Fish Cut, on account of the thousands of beautiful and perfect impressions of fishes which are shown on the surface of the thin slabs, sometimes a dozen or two on an area of a square foot. Impressions of insects and water plants are also found, as well as of a remarkable specimen of a feather of a bird, which Professor Marsh regards as a unique specimen, forming a most interesting addition to the bird remains of North America. "It is the distal portion of a large feather, with the shaft and vane in such excellent preservation that it may perhaps indicate approximately the nature of the bird to which it belonged." My collection of fossil fishes from this cut is very large, and my success was mostly due to the kind aid of Mr. A. W. Hilliard, a gentleman of intelligence, who superintended the excavation along the line of the railroad, and preserved from time to time such specimens of value as came in his way. If the example of Mr. Hilliard had been imitated all along the line of this railway thousands of most valuable specimens would have been preserved which are now lost to science. The existence of such vast quantities of animal life, during this period, as those shaly layers would indicate, may account for the oily nature of much of this rock. In a portion of this cut there is an apparent dip northwest about 18°, but I am disposed to regard it as local. At the west end of the cut are some singular, dike-like openings, filled with loose material from the rusty sandstone near the top of the hill. These fissures are evidently due to jointage, and appear like regular mineral lodes with well-defined walls. In most cases they extend up through the shaly layers to the rusty-yellow arenaceous marls, and these fissures have been so closely filled with this material that it must have occurred from deposition, that is, the fissures were formed before the deposition of the calcareous sandstone above.

For a most interesting account of the fossil fishes of this group the reader is referred to the essay of Professor Cope in Part IV of this report.

About a mile west of the "Petrified Fish Bed" is a cut along the railroad which passes through a moderate thickness of buff, chalky limestones, filled with impressions of leaves of deciduous trees. These rocks hold a position about one hundred feet above the petroleum shales which contain the fish remains, and therefore the date of their existence may be regarded as subsequent, though belonging to the same basin. Professor J. S. Newberry, our best authority on the fossil vegetation of America, has given these plants a hasty examination, and communicated the following interesting notes in the form of a letter:

I have examined the plants from the Green River beds with as much care as the limited time at my command would permit, and am surprised in not finding among them a single species contained in any of your other great collections at the far West. They thus far afford no certain criteria for collating the Green River tertiaries with those of other localities where you have studied them. The plants from the rocks inclosing the coal at Marshall's mine are more significant, as they include species (*Platanus haydeni*, which is certainly different from *Platanus aceroides*) such as were found by you at Carbon Station and at the mouth of the Yellowstone. Every collection of fossil plants received from the tertiary of the West brings to light many new species, and the great diversity which they exhibit proves either a number of plant-bearing horizons, or great localization of the species in the tertiary flora.

Among your Green River plants are only some half dozen species so well preserved as to be capable of satisfactory identification or comparison, but they form a very interesting group. Among them I find two palms, both quite unlike anything before found on this continent. One is a new *Phenicites*, resembling Heer's *Manicaria formosa*. The other but an imperfect fragment, yet altogether new and strange to me. The most abundant species contained in the collection is a *Magnolia*, allied to *M. tenuinervis*, Lesq., but more elongate and acute; also an oak resembling *Quercus Saffordi* of Lesq. There is another oak in the collection, a laurel, (probably,) and fragments of two ferns, too imperfect for determination. On the whole, these plants resemble most those described by Lesquerenx, from Mississippi, and I am inclined to suspect are of the same age. This would make the Green River beds older than you have thought them, and I should want more material before venturing anything more than a suggestion to that effect. I trust you will be able to make other collections from these plant beds during the present season.

The specimens contained in the buff, marly limestones of the Green River series are generally not well preserved, and yet, I think, careful search at the locality where these plants sent me were obtained would result in the discovery of some fine things. I would especially urge a search for fruits.

The aspect of the small group of plants now before me from Green River is more tropical than any you have brought from the West, and as we have reason to believe that our eocene climate was warmer than the miocene, and that from the eocene epoch to the glacial period a progression of temperature took place, the Green River beds would seem to me to prove earlier than late miocene.

Geologists have as yet explored this interesting region only in the most superficial way, and we have caught but a glimpse of the wonderful treasures which will some time be brought to light. The strata are nearly horizontal, and the rivers have cut such deep channels in them that they can be studied with comparative ease. Professor Denton, who made an exploration of the country about one hundred miles south of the railroad, has given a graphic account of his discoveries, which shows very clearly the geographical extension of this formation. Near the junction of White and Green Rivers, partly in Colorado and partly in Utah, he describes an immense tertiary deposit, composed of a series of petroleum shales, one thousand feet in thickness, varying in color from that of cream to the blackness of cannel coal. The shales abound in the impressions of leaves and of various species of insects. Mr. Samuel H. Scudder, of Boston, published in the American Naturalist for February, 1868, a most interesting account of the insects collected by Professor Denton. He says:

The masses of rock were crowded with remains of insects and leaves of deciduous trees. Between sixty and seventy species of insects were brought home, representing nearly all the different orders; about two-thirds of the species were flies, some of them the perfect insect, others the maggot-like larvæ, but in no instance did the imago and larvæ of the same insect occur. The greater part of the beetles were quite small. There were three or four kinds of *Homeoptera*, (allied to the treehoppers,) ants of two different genera, and a poorly-preserved moth. Perhaps a minute *Thrips*, belonging to a group which has never been found fossil in any part of the world, is of the greatest interest.

At the present day these tiny and almost microscopic insects live among the petals of flowers, and one species is supposed by some entomologists to be injurious to the wheat; others believe that they congregate in the wheat as well as in the flowers, in the hope of finding food in the still smaller and more helpless insects which are found there. It is astonishing that an insect so delicate and insignificant in size can be so perfectly preserved in these stones; in the best specimens the body is crushed and displaced, yet the wings remain uninjured, and every hair of their broad but microscopic fringe can be counted.

Professor Denton also discovered in this region a deposit of petroleum coal, which appears identical with and would yield as much oil as the Albertite coal of New Brunswick. Another bed, resembling cannelite, was noticed, ten to twenty feet in thickness, which Professor Denton believes would produce fifty or sixty gallons of oil to the ton. If so, a single bed here would yield twenty million barrels of oil, or a thousand times as much as America has produced since petroleum was discovered in Pennsylvania. It is clear that these shales, with the fossil insects, leaves, and petroleum, are only a southern extension of the beds which we have so fine an opportunity to study around the Green River Station. Dr. Palmer has brought fresh water shells, as *Goniobasis Carteri*, and others from White River, which tends to strengthen this conclusion.

From Bryan we pass over a peculiar region, differing again in its surface features from any previously seen on our route. Far distant to the southward the singular, dome-like appearance of what we have usually styled the "bad lands" is visible, their brown and indurated sands and clays having weathered into remarkable forms. One of these singular hills forms a noted landmark along the old stage road, which has received the name of "Church Buttes," from its supposed resemblance to a church. To this formation I have given the name of the "Bridger Group," and I am convinced that this region was occupied by a vast fresh-water lake about the same time that the one on White River existed. From the indications derived from the fossil remains already discovered, this group of beds is destined to yield a fauna second only to that of the "bad lands" of Dakota. So far as yet known, all the remains appear to be of middle tertiary age. Among these fossils those of turtles are especially numerous. A multitude of fragments, together with several forms, nearly entire, have been collected and sent to Professor Leidy, of Philadelphia, for examination. The specimens have been referred to three extinct species; the greater number pertain to a fresh-water turtle which has been named *Trionyx guttatus*. The genus to which it belongs is found at the present time living in the rivers of America, Asia, and Africa. It is represented in our country by the *Trionyx ferox*, or great soft-shelled turtle of the Mississippi and its tributaries. The animal is noted for its voracity and feeds on fishes, snakes, and young alligators. Its ancestor of the Bridger tertiary period no doubt was equally predaceous in its habits.

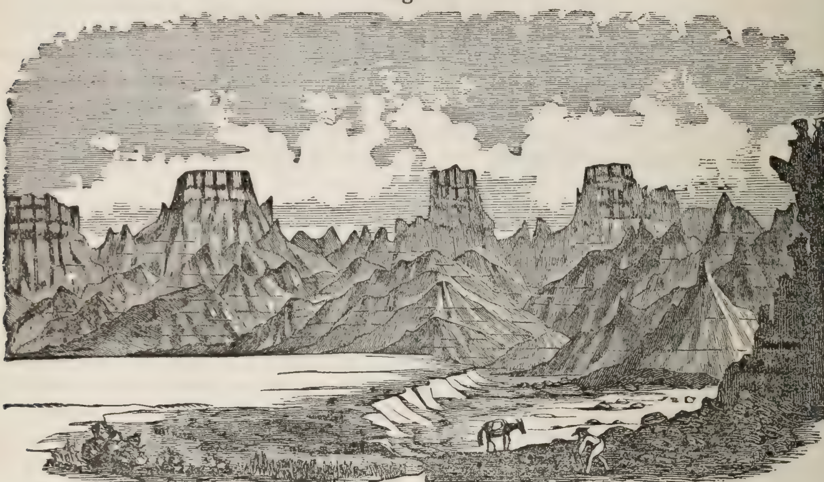
Another turtle, of which a nearly complete specimen was discovered, was more like our marsh terrapins in character. It, however, belongs to an extinct genus and species, to which Professor Leidy has given the name of *Baptemys Wyomingensis*, from the habit which it no doubt possessed, in common with most of its tribe, of at least taking an occasional plunge in some convenient bathing place. Some of the nearest living relatives to this turtle are now found in Central America, the so-called *Dermatemys* and *Staurotypus* of Vera Cruz and Tobasco. The third species of turtle indicated by fragments Professor Leidy has referred to a terrapin which he has named *Emys Stevensonensis*, in honor of James Stevenson, the companion and able assistant of the author during his geological explorations of the interior of our continent.

From other fossil remains from the Bridger Group of rocks, Professor Leidy reports the former existence of an animal presenting an affinity to the hyena and panther. It was larger than our species of the latter, and was evidently a predaceous animal of great strength and ferocity. It has been named *Patriofelis ulta*, which signifies the ancestral cat that hath revenged itself. The remains of a small animal discovered by Mr. J. A. Carter, of Fort Bridger, and sent to Professor Leidy, were referred by him to an insect-eater related to the European hedgehog, to which he has given the name of *Omomys Carteri*, in honor of its discoverer.

It will thus be seen that all the animals indicated by the fossils from the Bridger bed, comprising three different turtles, a carnivorous and an insectivorous mammal, are of species and genera previously unknown to science. They, therefore, indicate an especial fauna, accompanied by a peculiar flora, of which thus far we have seen but a trace. Further researches will most probably give to us an interesting history of the lost race of animals, of the former existence of which we now have an intimation. Figure 13 presents a most excellent view of the "bad lands" as seen on White River, Dakota. This illustration may be regarded as a typical one of the style of surface erosion of the White River and Bridger Groups. The original sketch was taken on the spot by Mr. F. B. Meek in 1853, and is published by permission of Professor James Hall, of Albany, New York.

There are also beds of limestone, composed entirely of a small species of *Cypris* which gives to the rock a beautiful oölitic structure. Of fresh-water mussels, *Unios*, *Goniobases*, *Viviparas*, *Planorbis*, several species are found at different localities. Sometimes the *Goniobases* and *Unios* are found on a slab of limestone in great numbers, filled with chalcedony. All the evidence that we can secure, points to the conclusion that all the sediments of the Bridger Group were deposited in the bottom of a purely fresh-water lake, with no access to salt or even brackish water from any point. In regard to the extent of this great and most interesting lake basin very little is known. All the explorations have been, hitherto, of a hurried and superficial character. We believe that the Uinta Moun-

Fig. 12.



tains form the southern shore, and that it extends down to the valley of Green River, at least to the entrance of White River, and probably further. Professor Denton's graphic description satisfies us that the formations are identical with those around Church Buttes:

Looking from the summit of a high ridge on the east, a tract of country containing five or six hundred square miles is distinctly visible. Over the whole surface is rock, bare rock cut into ravines, cañons, gorges, and valleys, in magnificent relief—terrace upon terrace, pyramid beyond pyramid, rising to mountain heights; amphitheaters that would hold a million spectators; walls, pillars, towers, castles everywhere. It looks like some ruined city of the gods, blasted, bare, desolate, but grand, "beyond a mortal's telling." Originally an elevated country, composed of a number of soft beds of sandstone of varying thickness and softness, underlaid by immense beds of shale, it has been worn down and cut out by rills, creeks, and streams, leaving this strange, weird country to be the wonder of all generations.

But we must not leave this singularly interesting region without a word in regard to the "moss agates" which cover the country from Green River to Fort Bridger in the greatest profusion. The ground in many places seems to be literally paved with nicely-rounded pebbles and small boulders, mostly of agate flint, the largest not more than four or five inches in diameter; there is a belt of about ten miles in width, from east to west, including Church Buttes, and extending an unknown distance, from north to south, over which these gems are found in the greatest abundance and variety. I am inclined to think they originate in this modern tertiary formation. About six miles west of Carter's Station a cut in the railroad reveals a bed of tough, dark-gray, plastic clays, and at the top a layer of flinty concretions filled with small seams of chalcedony. In the "bad lands" of White River are abundant seams of fine chalcedony, which only need the oxide of iron or manganese to make the choicest of moss agates. I am inclined to believe that these agates originate in irregular seams in the tertiary beds somewhere south of Church Buttes. The origin of all the drift material which strikes the eye everywhere I regard as local, and that it was probably transported from the direction of the Uinta Mountains.

Some of these gems are very beautiful, and the sprangles or dentritic delineations are wonderfully like the stems of moss, and it is quite difficult for most travelers to believe that they are not actually plants imprisoned in the flinty mass. Most of the agates are of little value, but occasionally one is found of great beauty that will sell for $50 or $75. They are also found in the Middle and South Parks to some extent; those in the Middle Park being regarded as by far the best. Beautiful specimens of opal, semi-opal, or opaline, occur, and when found are especially attractive. A variety of opal of a milky-white color, and very transparent, was found in a lode of gold-bearing quartz, near Idaho, Colorado, and was much sought after for a time.

CHAPTER XII.

BEAR RIVER TO GREAT SALT LAKE VALLEY.

For more than two hundred miles we have passed over what appears to be one of the most desolate regions of the West. Even the most enthusiastic of our companions in travel will not hesitate to pronounce it a desert. Yet a careful analysis of the soil will show that it possesses the elements of fertility. If streams of water could be made to circulate through these broad, treeless, and almost plantless plains, and the same amount of human industry employed as has been so remarkably exhibited by the Mormons in Salt Lake Valley, there is no doubt they would become productive. Whether in the great future this state of things can be brought about by artesian wells and cheap labor is a question for the people of that future to determine. It is my duty simply to present the facts as I read them. As we proceed westward from Fort Bridger, we note at once the favorable change that takes place in the aspect of the country and of the vegetation. Broad plains and sloping hills, crowded thickly with grass, with an almost entire absence of the wild sage, are now the rule. Patches of the quaking asp appear here and there, and along the streams are fringes of the cottonwood.

Soon after leaving Carter Station, toward the west, the pinkish beds come in suddenly. They seem to rise from beneath the Bridger Group. Their dip is about northeast 3° to 5°, and they have evidently been disturbed slightly by the later movements which elevated the Uinta range. This series of strata, to which I have given the provisional name of the Wasatch Group, are composed of red, indurated, arenaceous clays, with beds of grayish and reddish gray sandstones alternating. Pinkish and purplish clays are the dominant features, and give the lithological character to the groups as far west as Echo Cañon, when the conglomerates prevail. The latter group is full of beds of sandstone, largely concretionary, but the sandstones or harder layers are seldom of a reddish color. Before reaching Bridger Station the strata on either side of the road are horizontal, or nearly so. A long flat ridge extends down a little east of north from the Uinta Mountains, between Black's Fork and the Muddy. This may be regarded as the geological divide between the waters of the Great Salt Lake Basin and the drainage of Green River. The Muddy is one of the branches of Black's Fork, which flows into Green River, and west of this stream we have what is called the eastern rim of the Great Basin of Salt Lake. If we were to travel southward to the foot of the Uinta Mountains from the railroad along this divide, we should be able to detect no well-marked line of separation between the

Green River Group and the Wasatch Group. Bridger's Butte, as well as the entire eastern portion of this divide fronting the valley of Black's Fork, exhibit a large thickness of the somber, indurated sands, clays, and sandstones of the Bridger Group, passing down into light, buff, chalky layers, with *Planorbis*, *Unio*, *Helix*, *Goniobasis*, &c. Within a distance of ten miles to the west of this butte the little streams cut through the pinkish beds of the Wasatch Group, then pass up into whiter, indurated, marly clays, with numerous concretionary layers, differing from the chalky beds of the Bridger and Green River Basin. I am inclined to the opinion that this divide forms the junction of the shores of two great fresh-water-lake basins which existed during the upper miocene period; that here the sediments of the western shore of one were so mingled with those of the eastern shore of the other that they cannot now be separated.

The two great basins may have been connected with each other at different points at some stages of their growth, but there is an abrupt, persistent, very marked difference in the character of the sediments of the two basins. That the two great basins must have been synchronous is inferred from the fact that the strata of both have been but slightly disturbed by the elevation of the mountain ranges in the vicinity. The want of conformity of the Wasatch Group with the cretaceous and eocene beds will be shown hereafter to be well marked in a number of localities. Both the Bridger and Green River Groups have yielded many organic remains, but the Wasatch Group, although it occupies a very large area, and has been excavated to a great extent along the line of the railroad, has never, to my knowledge, afforded any distinct paleontological evidence of its age. Near Piedmont Station, in some arenaceous clays which had been taken out of a cut, I found a few fragments of turtle shells, which do not differ from those so common in the Green River district. It seems that, throughout the West, rocks which are characterized by this brick-red coloring matter are destitute of organic remains. The red beds, or supposed triassic, which are so conspicuous all along the flanks of the mountain ranges, are also singularly destitute of fossils. It seems that wherever this ochreous color prevails in the sediments, the physical conditions were not favorable for the existence of animal life, for if life existed, I can see nothing in the composition of the rocks why the remains should not have been preserved. At Bridger Station, and from Bridger to Aspen, which is about twenty-four miles west from Bridger Station, the ochreous beds of the Wasatch Group are well exposed on both sides of the road, and will attract the attention of the traveler. A few stunted cedars grow upon the hills and in the valleys and plains. The alkali is as abundant as ever. There are also localities where heavy deposits of drift occur, especially in the valleys of the streams. This is shown along the road wherever extensive excavations have been made, and these deposits will be simply mentioned from point to point, to be referred to hereafter in another connection.

The valley through which the road passes from Piedmont to Aspen is carved out of the beds of the Wasatch Group, and varies somewhat, but seldom over a mile in width. The little stream that flows through the valley is not more than ten or fifteen feet wide. From Aspen to Evanston the change in the general appearance of the surface of the country will be noticed at once. The hills are more rounded and more thickly grassed over, presenting an older appearance. At Aspen the cretaceous makes its appearance. The high hills on either side are composed of cretaceous strata which seem to have been higher points before the deposition of the sediments of the Wasatch Group, and also to have been elevated to some extent since that time. For some distance west of Aspen the red beds fill up the irregularities of the cretaceous surface, but do not conform. About half a mile west of Aspen Station the road cuts through a large exposure of the lower cretaceous shaly clays of No. 2, revealing abundant fish scales and fragments of *Inoceramus.* These cretaceous beds are well shown for about four or five miles, when the coal beds make their appearance near Bear River. Near Sulphur Creek there is a ridge of sandstone which the road passes through nearly at right angles. This ridge, which I have called Oyster Ridge, trends about northeast and southwest, and the dip is west northwest 20° to 25°. It is composed mostly of gray and yellow gray sandstone, capped with a calcareous sandstone, filled with a small species of *Ostrea*, and belongs, I think, to the upper portion of the cretaceous group—probably No. 5. On the north side of the road there is a high range of hills which are made up of the black clays of No. 4. At Bear River City, which is not more than four miles to the west, the strata are nearly vertical and trend nearly northeast and southwest, with a dip northwest. There is here a series of strata, which are still invested with a good deal of obscurity. On the north of Sulphur Creek, for three miles before it unites with Bear River, the black clays of No. 4 are extensively exposed, and above them a series of sandstones with partings of clay, gradually passing up into the strata which contain coal. That a portion of these sandstones belongs to the upper cretaceous group I cannot doubt, but where the line of separation should be drawn between the cretaceous rocks and those of tertiary age I am unable to decide. In the bed of sandstone which rests upon the well-marked cretaceous clays are found a species *Ostrea* and a few other marine species of shells, none of which are really peculiar to the cretaceous, but from their entirely marine character we regard them as such. We then have from three hundred to five hundred feet of sandstones and clays, with thin beds made up of marine shells, and among them a species which sometimes reaches a length of twelve inches, which Mr. Meek has described under the name of *O. soleniscus.* In this group are a few thin seams of impure coal. The dip of these beds is northwest about 50°. Then comes a large thickness of arenaceous clays with thin layers of sandstone, with three or four seams of impure coal and large quantities of brown iron ore or limonite. The seams of coal are from one to three feet thick, with the usual clays above and below. Then comes the bed of coal which is well known in this region, seven feet thick, nearly vertical or with a dip of 82° northwest. The inclination of the entire series of rocks from the Uinta range is quite plain.

This coal bed has been wrought for several years, and is so convenient to the railroad that it ought to be of considerable value. The coal appears to be of good quality. Above and below it are thick beds of clay. In the clay above the coal there is a seam of oyster shells, a species distinct from any that occurs below it, about 4 inches thick. Above the clay there is a thick bed, two hundred feet, of gray sandstone, with irregular layers of deposition inclining at a very high angle—70° to 80°. Then a valley intervenes to the westward, in which Bear River City is located, one-fourth to half a mile in width, which must have once been occupied with a considerable thickness of soft material, which is now quite concealed by grass and other vegetation. Still further west we have a wonderful series of fresh-water beds, which have been tilted and flexed in a most remarkable manner. These are shown in a railroad cut a little west of the city, about two hundred or three hundred feet long, where nearly two hundred layers are exposed, of almost every variety of texture, from sandstone, clay, and fine sands, to earthy lignite, and many of these sands are so crowded with fossil shells that they may be gathered by the bushel. The sides of the cut are so peculiarly banded that they look like the stripes of a zebra. At the east end these layers are nearly vertical, but at the west end they seem to have been lapped or bent down so as to form an abrupt cone, as if there had been tremendous pressure from above. A little further to the westward we see a ridge of the red beds and conglomerates, inclining gently to the west, and resting unconformably upon the upturned edges of the rocks in the cut. But along no other portion of our route have I ever seen so rich a locality for fossil shells, of a few species. In the cut and on the hills on either side of Bear River the ground is literally paved with them, and the collector may gather them as he would the shells on the seashore. They are mostly land and fresh-water species, many of them as yet undescribed. Mr. F. B. Meek has made out a partial list, and he finds several species of fresh-water shells, as *Unio priscus*, *U. belliplicatus*, *Goniobasis chrysalis*, *Melania humerosa*, &c., and some interesting estuary forms which indicate brackish water, or partial access to the ocean in those times. The conclusion, however, is that all these rocks are of tertiary age.

The following sections of these curiously variegated strata were made at my request, by Mr. H. R. Durkee, a civil engineer of great skill in his profession, and an excellent geologist. They were wrought out with much care. The diagram will also assist in rendering more clear the position of the strata. The second cut has been exposed by the excavations for gravel made by the workmen on the railroad; so that both of them may be considered as artificial exposures.

COMMENCING AT THE EASTERN EXTREMITY OF THE CUT. SECTION 1.

No.	Description.	Thickness. Ft.	Thickness. In.
1	Clay, grayish-black, contains fragments of sandstone	10	0
2	Limestone, blue	2	0
3	Clay, grayish-black	0	6
4	Clay, brown, hard, and in large fragments	1	0
5	Clay, black, hard, and in small fragments	1	0
6	Limestone, blue, fossiliferous	1	6
7	Clay, grayish-black	1	2
8	Sandstone, fragmentary	0	2
9	Clay shale, gray	1	0
10	Clay, grayish-black, very compact	1	0
11	Clay shale, black	0	10
12	Marl, shells in fragments	0	8
13	Clay shale, black	0	6
14	Limestone, much shattered, and in angular pieces	2	0
15	Clay shale, black	0	10
16	Limestone, angular fragments	0	6
17	Clay shale, brown		
18	Limestone, slightly fossiliferous	1	6
19	Gypseous earth, contains crystals of selenite	0	3
20	White marl, shells fragmentary	1	0
21	Limestone, very fossiliferous	0	6
22	Clay shale, black	1	4
23	Limestone, very fossiliferous	0	2
24	Clay shale, brown	2	6
25	Sandstone, fragmentary	4	0
26	Clay shale, gray-black	2	0
27	Gypseous earth, layer of crystals of selenite on east side	0	6
28	Clay shale, contains streak of coal and gypseous earth	2	6
29	Gypseous earth, contains streaks of brown bituminous shale	0	8
83	Limestone, fossiliferous, fossils small	1	8
84	Gypseous earth, white	0	2
85	Clay, stony, bluish-gray	2	6
86	Clay shale, black	0	10
87	Limestone, fossiliferous	0	8
88	Clay shale, black	0	3
89	Limestone	0	4
90	Marly clay, black	0	2
91	Marl, light gray	0	2½
92	Clay shale, gray	0	4
93	Clay shale, black	0	4
94	Clay shale, gray	0	6
95	Clay shale, black	0	2
96	Gypseous earth, yellow	0	2
97	Clay shale, black	0	4
98	Gypseous earth, yellow	0	3½
99	Limestone	1	6
100	Clay shale, blue	1	0
101	Limestone	0	8
102	Clay shale, blue	0	8
103	Limestone	1	8
104	Marl, gray	0	6
105	Shale, black	0	2
106	Sandstone	0	3½
107	Marl	0	3
108	Shale, black	0	4
109	Marl	2	0
110	Shale, bituminous	0	1
111	Marl	0	2
112	Limestone	0	8
113	Marl	0	5
114	Limestone	0	6
115	Marl	1	0
116	Shale, black	1	0
117	Coal and shale	0	2
118	Limestone	0	11
119	Marl	0	6

No.	Description.	Thickness. Ft.	Thickness. In.
30	Clay shale, brown, very hard	1	6
31	Clay shale, black, bituminous	0	5
32	Marl, gray	0	2
33	Limestone	0	10
34	Clay, full of fossils	0	3
35	Clay shale, gray	1	0
36	Clay shale, blue	0	3
37	Sand, yellow	0	2
38	Clay shale, gray	1	0
39	Clay shale, gray, bituminous	0	8
40	Limestone, fossiliferous	0	6
41	Clay shale and marl, fossiliferous, less fossils on west side	1	6
42	Bituminous shale, contains streaks of black coal	0	4
43	Clay shale, blue	0	6
44	Gypseous earth	0	1½
45	Clay shale, blue	0	1
46	Marl	0	4
47	Clay shale, blue	1	0
48	Marl, yellowish-white	0	3
49	Sandstone, fossiliferous	0	9
50	Clay shale, blue	1	2
51	Sandstone, fragmentary	0	8
52	Clay shale, blue and yellow	0	6
53	Limestone, very fossiliferous	0	6
54	Clay, full of fossils	0	2
55	Bands, black, bituminous shale and marl	2	6
56	Marl	0	5
57	Slaty shale, black	0	6
58	Limestone, very fossiliferous	0	3
59	Slaty shale, gray	0	10
60	Shale, full of fossils	1	0
61	Clay shale, black	0	8
62	Clay shale, yellowish-brown	0	6
63	Clay shale, blue	0	6
64	Coal and yellow shale in streaks	0	10
65	Limestone, very fossiliferous	1	0
66	Marl	1	0
67	Limestone, slightly fossiliferous, fossils fragmentary	1	6
68	Nodular clay and shells, streaks of bituminous shale on the west side	0	10
69	Marl, yellow, hard	0	4
70	Marl, black, soft	0	5
71	Clay shale, black, bituminous	1	6
72	Gypseous earth, yellow and white	0	2⅓
73	Marl, hard	0	4
74	Marl, soft	0	8
75	Clay shale, gray	1	0
76	Clay and shale in bands	1	0
77	Marl	2	0
78	Gypseous earth, yellow	0	1
79	Marl	2	6
80	Clay shale, black and blue, in bands	4	0
81	Clay, stony, gray	2	0
82	Gypseous earth, yellow	0	3

No.	Description.	Thickness. Ft.	Thickness. In.
120	Limestone	0	10
121	Marl	1	6
122	Clay shale, variegated, (purple, yellow, &c.)	0	9
123	Limestone, slightly fossiliferous	0	3
124	Gypseous earth	0	6
125	Limestone, slightly fossiliferous	0	4
126	Marl, bluish-black, hard	0	2
127	Coal	0	¼
128	Gypseous earth	0	3
129	Coal	0	¼
130	Limestone	1	0
131	Marl and coal	0	2
132	Limestone	0	7
133	Shale, bituminous, black	0	10
134	Marl, hard	0	4
135	Shale, black	0	1
136	Marl	2	0
137	Shale	0	1
138	Limestone, very fossiliferous	0	4
139	Clay shale, blue, full of fossils	1	0
140	Shale, bituminous, yellow and black	0	3
141	Limestone	2	6
142	Shale, slaty, black	0	6
143	Shale, brown, full of fossils	0	3
144	Shale, blue	0	7
145	Marl	0	3½
146	Gypseous earth	0	1
147	Limestone, compact, streaks of marl and coal, which run out	3	6
148	Shale, slaty	1	2
149	Bituminous shale and brown coal	0	8
150	Limestone	1	0
151	Clay shale, contains scales of white gypseous earth	1	10
152	Marl, hard	0	3
153	Shale, fossiliferous	2	0
154	Clay, hard, fossiliferous	0	8
155	Clay shale, black	0	1½
156	Clay, hard, fossiliferous	0	4
157	Marl, gray	0	6
158	Marl, black	0	2
159	Gypseous earth, white	0	8
160	Clay, hard	0	8
161	Marl	0	1
162	Coal, brown	0	6
163	Clay	0	2
164	Limestone	3	0
165	Gypseous earth and shale	2	0
166	Limestone	1	6
167	Sandstone, yellow	0	2
168	Limestone	1	0
169	Gypseous earth and shale	0	8
170	Limestone	1	0
171	Clay shale	3	0
172	Bituminous shale	0	4
173	Limestone	2	0

From No. 173 to western end of cut, (which is made up of the reversed strata, but not in regular order, some seem to be pinched out.)

ORDER OF STRATA EXPOSED IN RAILROAD CUT, SECTION 2, (FROM EAST TO WEST.)

No.	Description.	Thickness. Ft. In.	No.	Description.	Thickness. Ft. In.
1	Drift, steel-colored	15 0	18	Shale, brown	2 0
2	Sandstone, white	12 0	19	Sandstone, yellow	6 0
3	Sandstone, yellow, containing fragments, No. 2	1 5	20	Shale, brown	1 0
			21	Sandstone, steel-gray	40 0
4	Shale, arenaceous, brown	9 5	22	Sandstone, white	6 0
5	Sandstone, coarse, yellow, in layers	1 0	23	Sandstone, gray	4 0
6	Sandstone, fine, yellow, in thin layers	1 5	24	Shale, earthy, black	1 0
7	Sandstone, coarse, containing irregular streaks of brown shale, which contains coal in fragments	2 5	25	Gypseous earth, yellow	0 5
			26	Shale, black	0 5
			27	Sandstone, contains shells in fragments	15 0
8	Sandstone, fine, white	18 0			
9	Sandstone, brown, contains brown marks resembl'g bark and branches	2 5	28	Shale, brown	1 0
			29	Clay, marly	1 5
10	Sandstone, steel-gray, contains streaks of No. 9	40 0	30	Sandstone, yellow	30 0
			31	Shales and clays, earthy	25 0
11	Shale, black, and sandstone, steel-gray	1 0	32	Shale, brown	6 0
			33	Sandstone and gypseous earth	20 0
12	Sandstone, fine, white	4 0	34	Shale, bituminous	1 0
13	Sandstone, in thin layers of variegated colors	6 0	35	Gypseous earth	3 0
			36	Sandstone, yellow	10 0
14	Sandstone, in broad layers of variegated colors	21 0	37	Sandstone, white	8 0
			38	Marl, containing shells	6 0
15	Sandstone, steel-gray	12 0	39	Gypseous earth	2 0
16	Sandstone, in thin layers of variegated colors	5 0		To end of cut, shale, clay, and arenaceous gypseous earth	60 0
17	Sandstone, steel-gray, in layers, (contains streaks of coarser yellow in layers)	35 0		Length of cut, 440 feet.	

There is here another interesting feature, the oil springs of Bear River, which have made this country famous for many years. More than twenty thousand acres of oil lands, in claims of one hundred and sixty acres each, have already been surveyed and located by different parties. Companies have been formed and shafts sunk, preparatory to an extensive business. The external appearances are certainly very favorable. A considerable quantity of the crude oil flows from these springs constantly, and accumulates in small depressions or in the channels of the stream. When the oil first issues from the ground it has a bright-green color, but it soon changes on exposure to a dark brown, and has a slightly aromatic taste and smell. Similar springs occur in the valleys of Wind River, of the Sweetwater, and also of the Arkansas River, near Cañon City, Colorado. At the latter locality about four thousand gallons of refined oil have been made per year for the past three years. It is readily purchased by the inhabitants of the country, who regard it in all respects as equal to our eastern oils for domestic uses. I will not here attempt to explain the origin of these western oils, but I suppose that they are derived from a similar source with those of the East. Geologists differ as to whether the oil is derived from vegetable or animal remains, but it is certain that it is not confined to any particular formation or geological period. In the valley of the Arkansas the springs are located in rocks of cretaceous age, while in Bear River Valley the oil flows up through tertiary strata, though in some instances it evidently rises from beds as old at least as the cretaceous.

About twenty miles west of Fort Bridger, on the Overland Stage road, there is a fine soda spring, yielding the most delicious water; it does not differ materially from that of the soda springs in the valley of the Fontaine qui Bouille, at the eastern base of Pike's Peak.

Bear River Valley has been noted for many years for its numerous mineral springs. Indeed, all Utah Territory is celebrated for them, but in times past the numerous springs in this valley have attracted most attention.

About ten miles below the station, on the right side of Bear River, is Medicine Bow Butte, which looms up conspicuously above the surrounding country, eight hundred to one thousand feet above the bed of the stream. It is undoubtedly composed, for the most part, of strata belonging to the coal series, which I am disposed to regard as of tertiary age. It is well grassed over, and is covered here and there with dense groves of quaking asp, &c.

Passing along the stage road westward from Bear Creek Station, over beds nearly horizontal, or inclining at a small angle, we suddenly come to an upthrust of rocks, called "The Needles," which the traveler coming from the East for the first time will regard with astonishment. Deep underneath an extensive covering of more recent deposits there seems to be an immense bed of coarse conglomerates, and at this locality, by upheaval, these conglomerates have been thrust up through the softer overlying beds in a nearly vertical position several hundred feet above the road, and have been weathered by atmospheric influences into a number of sharp conical peaks, which have given to this landmark the name of "The Needles." It is made up of all kinds of worn boulders and pebbles, like those we see forming the bed of any of our mountain streams, varying in size from that of a pea to a foot in diameter. These rocks are held together somewhat loosely by a kind of siliceous grit. Some of the worn masses are themselves an aggregate of worn pebbles, proving that a portion of the materials were derived from still older conglomerates. Sometimes there is a thin local seam of coarse sand containing only a few pebbles, but the greater part of the entire mass, five hundred to one thousand feet thick, is a coarse conglomerate. It is situated near the Yellow Creek Station, and the ridge of upheaval

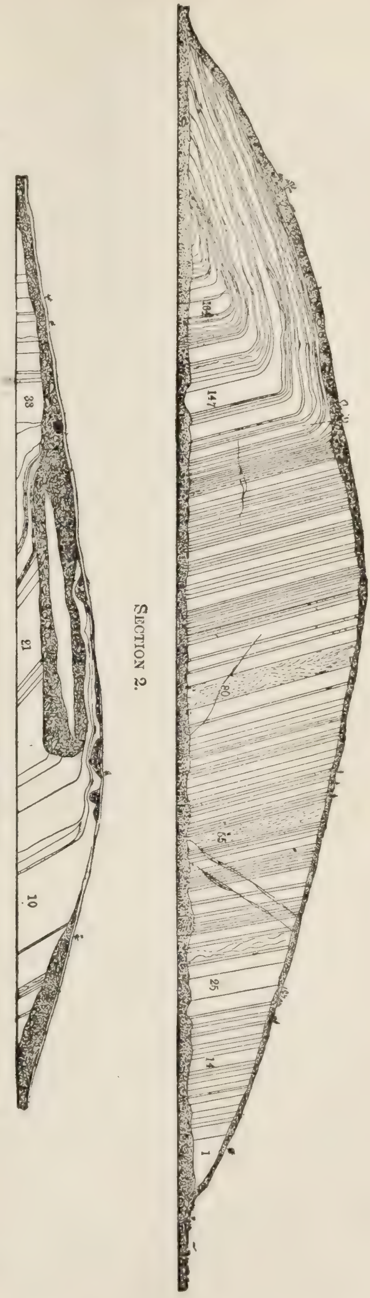


Fig. 15.

Section 1.

Section 2.

Sections taken at Bear River City, Union Pacific Railroad.

extends down from the Uinta range. As we go westward, examples of these massive conglomerates will not surprise us, and in Echo Cañon we shall find them three thousand to five thousand feet in thickness. They are probably all of modern tertiary age.

From the hills about a mile west of Yellow Creek Station we have some of the finest and most extensive views of the country. With a good field-glass we can see objects with considerable distinctness on a clear day for a distance of fifty to a hundred miles in every direction, over a most rugged surface with high ridges and deep gorges, the strata showing red, yellow, gray, and indeed every variety of color. Far to the south we can see the Uinta Mountains, their summits covered with snow the greater portion of the year, forming a most beautiful and symmetrical background to our view. To the southwest, dimly seen, is the Wasatch range, which separates us from one of the objects of our visit to this country—the Great Salt Lake. North of the road the Goose Creek Mountains are faintly visible, but still loom up with sufficient magnitude to invite our attention.

At Evanston we leave Bear River Valley and proceed on our way westward, while the river flows far northward into Idaho to Port Neuf Gap, near latitude 42½° N., then it suddenly and almost abruptly flexes about and flows southward until it empties into Bear River Bay, a portion of Great Salt Lake.

We may stop at Evanston and study the interesting coal mines with profit. With one exception this is the last point along the line of the road before reaching the Pacific coast, where we shall have an opportunity to examine coal mines possessed of any economic value. The coal is located about three miles from this place on the east bluff of Bear River Valley, and is exposed over but a small area. It seems to have been revealed by the inclination of the coal strata to the east, and the entrances have been made at the base of the bluffs but a few feet above the bed of the valley. A branch railroad has been constructed to these mines, and there is now no limit to the amount of fuel they can furnish.

The mines have been opened with more system and at greater expense, and I regard them as more valuable and the coal of a better quality than any I have ever seen west of the Mississippi. Five entrances have been made, each one showing a vertical front to the coal bed, varying from twenty to twenty-six feet. The dip is about northeast, and varies from 12° to 19°. For a distance of about a mile along this abrupt rocky bluff the coal seems to be exhibited on the grand scale above described, but proceeding either way from that point it disappears or becomes almost inaccessible. About one hundred feet above the coal bed there is a layer of calcareous sandstone filled with leaves, apparently belonging to extinct species of the genera *Magnolia*, *Tilia*, *Salix*, *Ulmus*, and *Platanus*, though very much resembling in form those of our existing forest trees. These leaves indicate that the rocks are of a tertiary age.

The summits of the hills are capped with a thick bed of conglomerate, probably of the same age with that which forms "The Needles" near Yellow Creek, and also that shown so grandly in Echo and Weber Valleys. At this point there is a broad expansion of Bear River Valley, which makes it a most attractive site for a city. There are here thousands of acres of fertile land that could be easily irrigated, and even now they form a vast meadow, covered during the summer and autumn with a luxuriant crop of grass.

From Evanston we might branch off in any direction and visit places of great interest of which but little is known as yet. Not far northward we might take a glance at Bear Lake Valley, which is destined to be a point of great interest, not only to tourists from the grandeur of the scenery and the beauty of the lake from which it takes its name, but also to settlers on account of the fertility of its soil. This lake is an expansion of a branch of Bear River, and is about fifteen miles long and four or five in width, and well stocked with trout. About thirty miles to the north are the far-famed soda springs of Idaho, which will repay the time spent in visiting them.

Taking the cars again at Evanston we shall soon find ourselves at the divide between Bear River and Echo Cañon at an elevation of about seven thousand feet above tide-water. The country we have passed over presents nothing new or striking; the same reddish clays and sands which we have seen before, seem to have been worn down into a fine rolling surface, which is covered with a good growth of grass, giving the whole scene a cheerful aspect. Game, as antelope, elk, deer, bear, &c., was formerly abundant all over this region, and the experienced wary hunter might discover some even at this time; but all along the line of the railroad game of all kinds is fast disappearing.

The tunnel at the head of Echo Cañon is cut through the reddish and purplish indurated sands and clays of what I have called the Wasatch Group, of miocene tertiary age. It is seven hundred and seventy feet in length, and is the longest tunnel on the Union Pacific road. After passing through it, the trains move slowly over the piers of trestle-work, which creak and tremble beneath their load. One section is two hundred and thirty feet long and thirty feet high, the other four hundred and fifty feet in length and seventy-five feet high. We then enter one of the narrow grassy valleys which leads soon into Echo Cañon, and then we sweep rapidly down between lofty conglomerate walls on either side, which have been weathered into the most fantastic forms.

Indeed, this entire valley is, for the most part, one of erosion. The water in past geological times has carved out of the massive conglomerates its deep channel, and on either side the rocks rise wall-like five hundred to one thousand feet. Some portion of the lower part of the valley passes through a monoclinal rift; that is, the beds incline to the northwest, so that on our right as we descend we see the projecting edges. All these beds seem to have a greater or less dip to the northwest, apparently from the Uinta range.

At the head of Echo Cañon the first objects that attract our attention are the massive reddish sandstones on our right, five hundred to eight hundred feet high, which have weathered into curiously castellated forms, and to which the general name of Castle Rock is given. As we pass down through some of the wildest scenery in the world, our eye will be constantly arrested by some unique shape into which these variegated sandstones and conglomerates have been worn by time. Witches' Rock, Eagle Rock, Hanging Rock, Conglomerate Peaks, Sentinel Rock, Monument Rock, all greet us in turn as important landmarks.

The Conglomerate Peaks of Echo present a near view of these conglomerates, so that even the depressions in the smoothly-worn surfaces of the boulders can be distinctly seen. A little side stream has worn a deep gorge, and scattered vast piles of debris below. The different sizes of the pebbles are also well shown; its walls are about five hundred feet high.

Monument Rock is one of the most remarkable landmarks in this valley. It is a regular obelisk of conglomerate, standing at the junction of the Echo with the Weber Valley, nearly one thousand miles west of

Omaha. It is about two hundred and fifty feet high, and forms another illustration of the peculiar style of weathering by which rocks assume the appearance of animals. This column has been very aptly called the Dog's Head, to which it will be seen at a glance that the summit bears a resemblance.

The peculiar form of stratification, with the varied texture, sometimes a fine sandstone, then a fine pudding-stone, is well shown in many localities, and the same variations of structure on a still larger scale may be seen throughout the valley of Echo and portions of Weber Cañon. The inclination of the strata is also well shown. The base is composed of rather fine sandstone, but these sandy layers are not permament over areas, but often within a distance of a few feet run into coarse, massive conglomerate.

Hanging Rock presents to us one of the most striking views in this region, and is a mass of coarse conglomerate, overhanging its base about fifty feet. It overlooks Echo City and the valley of Weber, through which a beautiful stream of pure mountain water winds its way. On the opposite side of the Weber the partially-rounded, grassy foot-hills of the Wasatch Mountains may be distinctly seen. The Weber River also flows a portion of its way through a monoclinal valley, the abrupt, nearly perpendicular sides of the conglomerate bluffs rising up like gigantic walls eight hundred to one thousand feet, while on the left the gently-sloping sides of the inner series of ridges are well displayed. The isolated rounded mass, which seems to stand alone, and almost ready to tumble into the valley below, is quite firmly seated on its bed of sandstone, and the corresponding portions may be seen forming the base of the hanging rocks. I call attention to these strata of sandstone as a matter of geological interest. High above the bed of the Weber, eight hundred feet or more, rises the conglomerate bluff, with nearly perpendicular sides, and from its summit one can survey the country for a long distance in every direction, and enjoy the multitude of most attractive views offered.

As we descend Echo Valley, we emerge from the cañon around Pulpit Rock, and shoot our way with wonderful rapidity down the picturesque valley of the Weber. We shall observe that, as we descend the Echo Cañon, the more rugged picturesque scenery is exhibited on our right hand, and as we descend the Weber, the same lofty perpendicular walls, weathered here and there into all sorts of fantastic forms, continue to the Narrows, where the Weber River makes a bend to the left, and the conglomerates disappear. This formation, which in some respects is the most remarkable one which I have ever seen in the West, must have a thickness of three thousand to five thousand feet. The conglomerate portion above must be one thousand five hundred to two thousand feet in thickness. I have included in this group all the variegated beds which we have observed west of Carter's Station, and we have noticed especially that some shade of red has prevailed in the clays and sands, as well as in the conglomerates of this group. Some of the sandstones in the upper portion of Echo Cañon are noticeable for their deep yellow hue. I have called this series of beds the Wasatch Group. How great the area occupied by these formations I have never ascertained. I regard them, however, as forming the materials deposited in one of the great lake basins of the middle tertiary period, the history of which, if we knew it, would be too long and tedious for this volume. But if fine sands require moving waters for their deposition, what kind of aqueous forces must have been employed to transport these boulders into this lake-basin? From whence were they derived, and what were the powers that wrenched them from their parent beds, smoothed them into their present rounded form, and then aggregated and cemented them together into such huge masses as we find here?

From the mouth of Echo up the valley the rocks seem to form a sort of gentle anticlinal for about ten miles, and then the inclination is reversed. The general dip, however, is 5° to 15° nearly northwest; but for six miles below and three miles above Hanging Rock, it is increased to 25°, and even to 35°.

This formation, which differs somewhat lithologically from any with which I am acquainted, must have an aggregate thickness of at least three thousand feet. The conglomerate portion must be at least fifteen hundred feet in thickness. It includes no beds of coal, and shows a few fossils, which are all impressions of deciduous trees, but no marine or fresh-water shells.

Near Coalville, a little town in the valley of Weber River, five miles above the mouth of Echo Creek, coal outcrops several times. At Spriggs' Opening the dip is 20° or 30° east, and the coal bed about fifteen feet thick, capped with gray sandstone, much of it charged with pebbles. I was informed that in other places this pebbly sandstone rests directly on the coal bed. A few hundred feet from Spriggs' Opening a shaft to strike the same bed has been sunk seventy-nine feet deep, through twelve feet of gravel and sand, into black clay, growing harder downward, and containing numerous specimens of a species of *Inoceramus*, *Ostrea*, and Ammonites, showing that the black clays are certainly of cretaceous age. If these beds do actually lie above the coal, as the dip would indicate, then this formation of doubtful age, must be cretaceous, and some of the finest coal beds in the West are in rocks of that age. It is probable, however, that the coal is really above the black cretaceous clays of No. 2, and forms a part of the upper cretaceous group.

The Weber River flows directly west, and the rocks incline in a sort of half circle between north and south. Several beds of massive sandstone cap the high hills, and between them are layers of clay with a reddish tinge. I was informed that there were in this section six or seven beds of coal, varying in thickness from eighteen inches to fifteen feet.

Passing down the Weber Valley the dip would carry down the Coalville coal beds, in a distance of five miles, that is, at Echo City, to a depth of from twelve hundred to fifteen hundred feet beneath the surface. So that the coal area that can ever be made available for economical purposes in this region must be very limited.

An interesting feature along the Weber River is its terraces. Near Echo City there is a rather narrow bottom near the river; then an abrupt ascent of thirty feet; then a level plain or bottom of two hundred to four hundred yards; then a gentle ascent to the rock bluffs. The summit of the first bluff at Echo is five hundred feet high; it then slopes back to the plains beyond.

Passing down the Weber Valley, about a mile below Echo Station the beds begin to dip 25° northeast. The whole valley is filled with rounded boulders, some of them three to four feet in diameter. The Weber River throughout the greater part of its course seems to flow through a monoclinal valley; but just before reaching the entrance of Lost Creek it seems to pass along a local synclinal valley. A long ridge of conglomerate extends down from the direction of the Wasatch Mountains, nearly northeast and southwest, inclining northeast 5° to 10°. At this point the Weber, instead of continuing in the synclinal valley, cuts through the ridge, isolating a portion about half a mile in length and forming a huge chasm or gorge, which is called here the Narrows. After passing through this ridge the Weber receives Lost Creek, and makes an abrupt bend to the southward; and here is exposed an immense thickness of the older rocks, in a nearly vertical position. These rocks extend down the Weber River four miles or more, when the beds abruptly change from the nearly vertical position to a nearly horizontal one.

Commencing near the Narrows, at the mouth of Lost Creek, we have a considerable thickness of the Jurassic limestones and marls, dipping 70° or 80° northeast, of a bluish ash color, very hard and brittle, cleaving into thin layers and fracturing in every direction, so that the sides of the hills are covered to a great depth with its debris. Then comes a series of mud shales, with ripple marks, some layers of very white sandstone, and a thick bed of hard red sandstone, destined to take the highest rank among the building stones of Utah. It can be easily wrought into fine forms for culverts, fronts for buildings, caps and sills, &c. Then comes a vast thickness of gray and dark-gray, more or less cherty limestones, which are probably carboniferous; and below these again a very hard siliceous rock, oftentimes massive, portions of which are filled with holes at right angles to the layers, very similar to much of the Potsdam east of the Mississippi, pierced by *Scolithus linearis*. In this quartzose group there is a bed of shaly limestone, six to ten feet thick. A few indistinct mollusks were observed in the limestones and the mud shales.

The distance from the mouth of Lost Creek to the end of the nearly vertical series of rocks is about three miles. So that we have here a thickness of strata not much less than two miles in thickness from the top of the Jurassic downwards, so as to include the carboniferous.

At the mouth of Lost Creek there is a remarkable example of nonconformity in hills of different ages. The reddish conglomerate rests directly upon the upturned edges of the vertical beds described above, and it is an important question what has become of all the intermediate beds, containing the coal, which are so conspicuous about five miles above Echo City.

Descending the Weber from the Narrows, we find some of the most remarkably rugged scenery in the West. The walls are very noticeable, and are formed of two beds of limestone, projecting from the sides of the valley at right angles, from between which ten or twelve feet of loose material has been washed out. Near the tunnels the rocks on the left side of the Weber dip about 10° nearly north, while on the other side the strata incline in the opposite direction 3° to 5°, as if the valley was anticlinal. Then again the valley would appear to be monoclinal, the strata on the right side of the river inclining 20° south, and on the opposite side, though presenting a nearly vertical front, inclining south also. A little farther on down the valley, and on the right side of the river, come beds of red sandstone; below these again gray sandstone, with a reddish tinge, the red sandstone dipping east 12°; while on the opposite side of the river the hills are open, rounded, and grass-covered.

The cherty crinoidal limestone extends to Morgan City and gradually disappears. The red sandstones are seen among the foot-hills.

At Morgan City we come out of the principal cañon of the Weber into a broad open bottom, filled with little villages and farm-houses. The soil is of great fertility. The hills on either side are smoothed off and covered thickly with loose material and vegetation. The high vertical exposures all disappear. The Wasatch range seems to trend nearly north and south; even the foot-hills of this range are so smoothed off and covered with drift, and then with grass, that the underlying rocks are not to be seen. The industry shown by the Mormons in this valley is worthy of all praise. The little streams are made use of to irrigate the rich bottom lands, which produce abundantly, and the houses look neat and comfortable. Fruit cannot be raised to any extent in the Weber Valley. The varieties of trees are confined mostly to the bitter cottonwood, although from Echo City down we meet with a small dwarf oak, box-elder, striped maple, and choke-cherry.

Just below the little village of Enterprise I saw in the hills, rocks composed of an aggregate of quartz pebbles. Still farther down we come to feldspathic rocks, indicating that the dip of the gneissic beds of the Wasatch range is westward. The Wasatch range is composed of gneiss, so far as the rocks can be seen along the Weber. The rocks are beautifully banded everywhere. There are also coarse aggregations of quartz and feldspar, with large masses of tourmaline; and all through the gneiss, are seams of feldspar and quartz of various thicknesses.

The evidence is quite clear that from Morgan City to the entrance of the Wasatch Cañon stretched a lake, the waters of which must have filled up the valley, rounded off the hills, and covered the sides of the mountains with loose debris. Along the sides of the cañon of the Wasatch, four and a half miles long, are thick deposits of loose sand, interspersed with water-worn boulders in many places. These deposits have been cut through in making excavations by the railroad, and the lines of current deposition are curiously well marked. About half way through the cañon there is a sudden bend in the Weber River, by which a small portion of one of the gneissic ridges is cut off. Opposite this ox-bow, a cañon descends the mountain side, down which a vast quantity of loose material has been swept, filling the channel of the river with local drift, and probably driving the current through the gneissic ridges. The Weber River, if its channel were straightened, would run through this deposit of drift, which is about thirty feet thick; instead of which it makes a bend and cuts its way through a massive gneissic ridge.

Extensive deposits of whitish, fine-blue and rusty-yellow sandstones, hard enough for building purposes, with flesh-colored marls, probably of pliocene age, and resembling very closely in many respects the more recent tertiary beds along the Platte, occur in this valley. These recent beds dip east or southeast. We thus learn that some of the later movements in the elevation of these mountain ranges have been of comparatively modern date. Terraces continue to show themselves the entire length of the Weber River, and they are probably synchronous with those which surround the basin of Salt Lake Valley.

After emerging from the Wasatch Cañon of the Weber valley, we pursued a southerly course along the base of the Wasatch range to Salt Lake City. For twenty miles or more all the unchanged rocks have been worn away from the flanks of the mountains, or completely concealed by débris. All over the gentle slopes at the foot of the mountains are strewn masses of rocks, all gneissic and evidently derived from the central parts of the mountains. Terraces surround this basin everywhere. There is one large one, with two or three smaller ones, on the sides of the mountains; and from the lowest one downwards the surface slopes gently to the lake. I was informed that the lake had risen nine feet vertically since 1868, and of course the water has aggressed upon the land to a great distance. I have heard no explanation of this phenomenon. All the lakes in the West are said to be rising more or less.

The carboniferous limestones begin to make their appearance along the flanks of the mountains about ten miles north of Salt Lake City, and continue to a greater or less extent all around the rim of the basin.

On the flanks of the mountains east of the city are the red beds, and probably a careful study would reveal Jurassic, cretaceous, and possibly even tertiary beds. President Young has long since offered a large reward to any one who would discover workable beds of coal within a reasonable distance of the city, and a thorough search has been made for them, but thus far without success. A bed of coaly clay only, has been found near the city in the mountains. All the coal used in the valley is transported in wagons from Coalville, on the Weber. The best of red sandstone for building purposes is brought from Red Sandstone Cañon, just east of the town. I think it is of Triassic age. The beautiful gray granite which is used in the construction of the Mormon Temple is brought from Cottonwood Valley in the Wasatch Mountains. It is composed of white feldspar, quartz, and black mica.

The surface of Salt Lake Valley has been rendered fruitful by the industry of the Mormons. Like the greater portion of the West, it was originally a vast sage plain. Now, by irrigation, all kinds of cereals and roots grow luxuriantly, and there are no better apples, peaches, plums, grapes, &c., raised in America. It may eventually become a vine-growing region.

Following the stage road eastward, sixteen miles from Salt Lake City to the Brewery at the mouth of Parley's Cañon, we reach the foot of the mountain, over sand beds which are probably of post-pliocene age. Here a little stream cuts through the sand beds, exposing a vertical bluff two hundred feet high, composed of fine sand, horizontally stratified and overlaid with a great thickness of water-worn pebble conglomerate. There are indications all along the flanks of the mountains that nearly or quite all the formations already recognized as far west as this point are here represented. At the entrance of the cañon the carboniferous limestones dip northeast 70° to 80°; over them lie the purple and red sandstones and rusty-yellow layers, and under them reddish shales. Beneath these shales an immense thickness of dark-gray silicious rock stands nearly vertical. All this vast thickness of older rocks, in appearance semi-metamorphosed, is undoubtedly the counterpart of the series described in the Weber Valley, just below the entrance of Lost Creek.

The road passes up a monoclinal valley between the ridges of quartzitic rocks, having a brittle fracture, and the monoclinal slopes are covered with debris. No gneissic rocks are noticeable along this road.

Before reaching the summits, in fact soon after we begin the ascent, we come to the conglomerates and sandstones which accompanied us down the Echo and Weber Valleys. Near the summit all the hills are rounded by erosion and grassed over, and water-worn boulders are scattered about here and there, so that the underlying rocks are partially concealed. Just beyond the summit we arrive at a broad open exposure in the valley of the stream called Parley's Point, half a mile wide and about seven thousand feet above sea level. Settlements are numerous all along the road; but while there is very good grazing, few of the cereals will grow.

All the rocks on the eastern slope incline at a greater or less angle apparently toward the east. Just as we enter Silver Creek Valley we come to numerous upthrusts of partially changed sandstones and conglomerates, the first indications that we get along our route of the neighborhood of igneous rocks. Some of the masses of rock which go to make up the conglomerate are of great size, very compact, and of a steel-gray color, and are inclosed in a steel gray silicious paste; but whether large or small, all are angular. These might be called volcanic conglomerates, for they are of igneous origin. They occur in the South Park and near the sources of Lewis's Fork of the Columbia River.

CHAPTER XIII.

GENERAL REVIEW OF THE GEOLOGY OF THE COUNTRY FROM OMAHA TO SALT LAKE VALLEY.

In the preceding chapters I have endeavored to present a simple statement of facts as I have been enabled to read them in nature. The simplicity and unity of the Great Rocky Mountain system is such, that when a sufficiently wide range of facts has been secured it will not be difficult to derive from them some generalizations of permanent value. In this chapter I desire to recapitulate somewhat briefly the principal geological features of the country from the Missouri to Salt Lake Valley, stopping here and there to discuss some obscure points.

The upper coal measure limestones are seen at Omaha, near the water's edge, and quarried all along the Platte nearly to the Elk Horn River. The lower cretaceous rusty sandstones of No. 1 overlap the upper carboniferous limestones about four miles above the mouth of the Platte, and extend to the mouth of the Loup Fork; but the yellow marl deposit, or loess, conceals for the most part the underlying rocks. A fine yellowish sand, of the same age, or a little less recent, overlaps the cretaceous near Columbus.

The chalky limestones of No. 3, with the characteristic *Inoceramus problematicus*, here and there crop out, and some obscure exposures have been detected in the Pawnee reservation, fifteen or twenty miles up the Loup Fork.

This fine yellowish sand soon gives place to the pliocene beds of the Platte, Loup Fork, and Niobrara Rivers, composed of indurated marls, sands, or sandstones, which continue on as far as the margin of the Laramie range of mountains, five hundred and thirty miles west of Omaha—that is, for nearly four hundred and thirty miles along the line of the railroad. In the grand anticlinal of the Laramie range, which I have already described, they sometimes repose with a slight discordance on the older rocks; sometimes, as near the Laramie Peak, they rest directly on the granites, and entirely conceal, for a distance of forty or fifty miles, all the unchanged rocks of older date; but a careful study of the eastern flank, from Red Buttes to Long's Peak, will reveal all the formations that are known to exist in this part of the West, inclining from the sides of the granitic nucleus at various angles.

Fig. 14.

Monument Creek, Colorado.

Figure 14 will illustrate the surface features of the Monument Creek Group. The rocks are composed mostly of decomposed granites, a feldspathic paste holding some pebbles of quartz or feldspar. The columns that are left standing over a large area, are capped with a hard layer of rusty yellow sandstone, as shown in the cut. This group covers the divide between the South Platte and the Arkansas Rivers, and is supposed to be of upper miocene or pliocene age.

Figure 15 will serve to show the appearance of the ridges of upheaval, or "hog backs," as they are sometimes called in the west. These ridges occur to a greater or less extent all along the eastern flanks of the Rocky Mountains. They sometimes rise like steps to the crest, so that one may walk from the tertiary formations in the plains, holding a horizontal position, across the uplifted edges of all the formations to the granite nucleus. Between these ridges are, in many instances, beautiful grassy valleys, varying from a few hundred yards to half a mile in width. When exposed only on one side of a range I have called them monoclinal ridges and valleys.

Fig. 15.

Ridges of upheavel near Big Thompson Creek, Colorado.

The railroad then for forty miles passes over and cuts through a great variety of syenites; some compact, beautiful building stones, almost equal to the Scotch syenites, but the greater part ferruginous and easily disintegrating on exposure.

On the west side of the Laramie range we pass across the uplifted edges of the various formations seen on the eastern margin. We know that the carboniferous limestones occur here, for the fossils which, though not abundant, are explicit as to their age. The limestones lie all along the margins of the Laramie range up to the Red Buttes, and sometimes slope so gently and cover the flanks so uniformly as to appear like a sort of flexible roof. Along the North Platte, above Laramie Peak, the little streams have cut deep cañons through the limestones and sandstones of carboniferous age. In Box Elder Cañon, *Hemipronites crassus*, *Productus semieticulatus*, *Aviculapecten occidentalis*, and other well-known carboniferous forms occur. Between the granites and the limestones is a thin series of fine and coarse sandstone, the layers resting directly upon the granites, being composed of a sort of fine puddingstone consisting of an aggregate of quartz pebbles and rusty coarse sand cemented with lime. This may possibly be a remnant of the Potsdam sandstone which occurs so well developed farther north in the Big Horn, Wind River, and Sweetwater ranges. This same sandstone is observed far north to Red Buttes, but I have never been able to find any trace of organic remains.

Fig. 16.

Uplifted Carboniferous Ridges, Jefferson Fork, Upper Missouri.

Figure 16 is introduced in this connection simply to show the ridges of carboniferous limestone, as they are revealed along the flanks of the mountains. This cut will apply to the ridges about ten miles west of Elk Mountain, although the sketch was taken in the valley of Jefferson fork of the Missouri River. Similar examples occur all along the east and west sides of the Laramie range. The figures are introduced in this connection to make more clear the theory of the upheaval of the Rocky Mountain ranges, which has been expressed in this and previous reports.

The red beds are well revealed all along the western flanks of the Laramie range, and are always noticed by the traveler on account of their peculiar brick-red color. The harder layers of this rock are much used for building purposes. I am unable to say yet whether these red sandstones are triassic or Jurassic, though I believe that between these and the cretaceous formations, Jurassic beds occur. Along the Big Laramie the cretaceous rocks come to the surface. The quartzites and sandstones which I have usually referred to No. 1, or lower cretaceous, underlie the plain just west of the railroad south of Fort Sanders; and in the banks of the Big Laramie, near the old stage station, No. 2, occurs with its dark plastic laminated clays, with thin layers of fibrous carbonate of lime, to the surface of which are attached great numbers of the ubiquitous *Ostrea congesta*. In the level plain west of the Big Laramie, No. 3 is exposed fifty to one hundred feet in thickness, with its usual yellow chalky character; the usual *Ostrea congesta* occurs in great abundance. Immediately along the line of the railroad no indications of No. 3 have ever been observed. Nowhere in the Laramie plains are any of the subdivisions of the cretaceous group well defined. These beds occupy the country along the line of the road from Laramie City nearly to Como Station, a distance of sixty miles; at this point the red beds and the true Jurassic rocks are brought to the surface, over a restricted area, by means of an anticlinal which forms a valley through which the road passes. The strata incline from either side. The south side of the road exposes the most complete series of beds; a high ridge is composed of Jurassic beds, mostly capped with the sandstones of No. 1, while as far as the eye can reach to the southward the low, wave-like ridges of No. 2 can be seen. Towards the southwest, the anticlinal valley seems to close up, but to the northeastward it expands indefinitely, and extends, no doubt, to the Laramie range.

From a point about ten miles west of Como to St. Mary's Station, a distance of fifty miles, the tertiary coal beds, with the sands, sandstones, and clays peculiar to them, occupy the country. The most important coal mines are located at Carbon; no shells have ever been observed in connection with the coal, but thousands of impressions of deciduous leaves are found. It is an important point to fix the age of the coal beds in any one locality. So far as we can determine, the coal beds of the Laramie plains are of eocene age, although the plants are more closely allied to those of the miocene period in the Old World.

In the vicinity of Elk Mountain, along the Overland stage road, in beds which I regard as belonging to the older tertiary, and holding a position near the junction of the tertiary and cretaceous, and nearly or quite on a parallel with the lower tertiary beds near Denver, Colorado, I found a quantity of fossil leaves, among which Dr. Newberry identifies *Platanus Haydeni*, *Quercus aceroides*, *Magnolia tenerafolia*, with fragments of *Cornus* and *Rhamnus*. The same species occur in the upper portion of the coal series on the west side of Bridger's Pass. At Carbon *Populus cuneata*, *P. Nebrascensis*, and *Platanus Haydeni*, are very abundant. From St. Mary's Station to Rawlings' Springs, a distance of thirty miles, the road passes over rocks of cretaceous age; although on the hills on either side remnants of the coal strata may be found. About two miles west of this point the coal beds begin to appear again, and at Separation, *Platanus Haydeni*, *Cornus acuminata*, with other undetermined species of plants, occur. This point forms the eastern rim of a basin which extends about one hundred and ten miles to the westward. A new group comes in which I have named the Washakie Group, from the fact that near this station are beds of calcareous sandstone and limestone, composed of an aggregate of fresh-water shells. As they are mostly casts it is difficult to identify the species, but Mr. Meek has named the most abundant kind *Unio Washakeei*. Soon after leaving Bitter Creek Station the coal strata of eocene age rise to the surface from beneath the miocene beds of the Washakie Group with a reversed dip. Here we find numerous beds of coal, and in the rocks above and below the coal are great numbers of impressions of leaves, and in the clay seams of oyster shells of several species. At Black Buttes Station, eight hundred and fifty miles west of Omaha, we found *Sabal Campbelli*, *Rhamnus elegans*, *Cornus acuminata*, *Quercus aceroides*, *Tilia antiqua*, with other undescribed species. At Point of Rocks, fourteen miles farther west, *Platanus Haydeni*, *P. Nebrascensis*, *Cornus acuminata*, *Magnolia tenerafolia*, occur. At Hallville the black slaty clays, forming the roof of one of the most valuable of the coal beds of this region, are crowded with bivalve shells, two species of which Mr. Meek has named *Cyrena fracta*, and *C. crassatelliformis*, regarding them as tertiary. They are undoubtedly brackish-water forms and show a sort of middle position—that is, middle or upper eocene. That there is a connection between all the coal beds of the West I firmly believe, and I am convinced that in due time that relation will be worked out and the links in the chain of evidence joined together. That some of the older beds may be of upper cretaceous age I am prepared to believe, yet until much clearer light is thrown upon their origin than any we have yet secured, I shall regard them as belonging to my transition series or beds of passage between the true cretaceous and the tertiary. When the large collections of fossil plants from the West, now in the possession of Dr. Newberry, are carefully studied, we shall have a much better basis upon which to rest a conclusion. It will be seen at once that one of the most important problems in the geology of the West awaits solution, in detecting, without a doubt, the age of the coal series of the West, and the exact line of demarkation between the cretaceous and tertiary periods.

The study of this question shows the importance of the continued accumulation of facts and the collection of organic remains. Neither can we place too rigid reliance on the teachings of the fossils, for it has already been shown many times that the fauna and flora of the tertiary deposits of this country, when compared with those of the Old World, reach back one epoch into the past. We have already obliterated the chasm between the permian and the carboniferous era, and shown that there is a well-marked inosculation of organic forms—those of supposed permian affinities passing down into well-known carboniferous strata, and admitted carboniferous types passing up into the permian. We believe that the careful study of these transition beds is destined to obliterate the chasm between the cretaceous and tertiary periods, and that there is a passing down into the cretaceous period of tertiary forms, and an extending upward into the tertiary of those of cretaceous affinities. It appears also, that every distinct fauna or flora of a period ought to contain within itself the evidence of its own age or time of existence, with certain prophetic features which reach forward to the epoch about to follow. If there is a strict uniformity in all the operations of nature when taken in the aggregate, as I believe there is, then this is simply in accordance with the law of progress which in the case of the physical changes wrought out in the geological history of the world has operated so slowly that infinite ages have been required to produce any perceptible change. The position that I have taken in all my studies in the West is that all evidences of sudden or paroxysmal movements, have been local and are to be investigated as such, and have had no influence on the great extended movements which I have regarded as general, uniform, and slow, and the results of which have given to the West its present configuration. The splendid group of fossils obtained on the Upper Missouri, from the Fox Hills Group or upper cretaceous beds, illustrate the prophetic element I have mentioned above. Among them are many true cretaceous forms, as *Ammonites*, *Baculites*, *Inoceramus*, &c., yet these all present such a modern facies that they seem plainly to look forward into the succeeding epoch, which in the case of our Atlantic coast was strictly marine. It was no fault of the fossils themselves that they were mistaken in this instance.

We may suppose that near the close of the cretaceous period, the ocean extended all over the area west of the Mississippi, from the Arctic Circle to the Isthmus of Darien. How much of the country east of the Mississippi was beneath the ocean I will not now attempt to determine. Restricted portions of the western continent may have been above the ocean level, and some of the mountains may have projected, like rocky islands, above the waters. Near the close of the cretaceous period the great water-shed of the continent was marked out, and the marine waters were separated into more or less shallow seas, lakes, estuaries, marshes, &c. Among the marshes sported the reptiles, the remains of which are so abundant in the tertiary deposits; and on the areas raised above the waters grew luxuriant forest trees and other vegetation which contributed to the formation of the coal beds. We shall attempt to show from time to time that, although the coal deposits of the West occupy an enormous area, yet the profitable deposits of coal lie in detached basins, some of which are quite restricted in their area. The study of these coal formations in nature shows most plainly that some of the beds of coal extend, uninterruptedly, over enormous areas, as if the vegetable matter had been deposited in a sea, or that the physical conditions attending its occurrence were widespread and uniform, while in other localities coal strata of great thickness clearly occupy but a limited area. We are aware that beds of coal, but a few miles apart, and evidently synchronous, show no physical evidence of ever having been connected with each other. There is another curious fact, that, while very nearly the same species of plants occur, the coal strata are nearly, or quite all, marine or brackish, while far removed from the mountain ranges the sediments very soon become purely fresh-water. On the Upper Missouri, where the coal-bearing group covers so large an area with remarkable uniformity, only the lowest beds contain marine forms, and very soon we pass up into strata with purely fresh-water fossils. We may suppose that at an early period, during the tertiary epoch, this portion was cut off from access to the salt water. If our ideas of the physical geography of these epochs are correct, coal strata of contemporaneous origin may be purely marine, purely fresh-water or brackish, depending upon the proximity of the sea, lake, or marsh, to the ocean waters.

We have already shown many times that there is no real physical break in the deposition of the sediments between the well-marked cretaceous and tertiary groups. In some localities the continuity is clear and beautiful in the highest degree. On Green River, and in the Bitter Creek Valley, one can trace the continuity step by step, so far as the strata are concerned, from the cretaceous through the greatest thickness of clays, sands, and sandstones of the lower tertiary to the purely fresh-water beds of Green River shales, Washakie or Bridger Groups. In these localities the influence of the elevation of the mountain ranges has been such as to expose the outcropping edges of all the strata from the cretaceous to the sands of the most recent tertiary, like the leaves of a book. We have already shown that in the clays interspersed among the coal beds in the Bitter Creek Valley, are seams of oyster shells of several species. A few other marine forms have been observed. At Hallville, near Point of Rocks, we have seen that in the slaty shales, above one of the coal beds, are proofs that at that period the physical conditions were most favorable for the existence of a profusion of brackish-water life; that in this locality, from 3,000 to 4,000 feet of coal strata were deposited before the salt water ceased to have access to these tertiary lakes. At Bear River, also, the same history is written upon the rocky layers. We have well-defined cretaceous strata, and from these we ascend through a series of sandstones and clays, with an abundance of shells of the genus *Ostrea*, and a few other marine forms resembling tertiary types as much as cretaceous. Soon we come to the coal beds, which, at this locality, are nearly vertical. Above them we find seams of oyster shells, but no other marine forms. And finally, high up in the upper beds of the coal group, we find the greatest profusion of brackish and fresh-water life that we have observed in the West, *Unio priscus*, *U. belliplicatus*, *Cyrena durkeei*, *Corbula pyriformis*, &c. So far as the Evanston coal mines are concerned, no shells have been found in connection with them, so far as I know. But last year, in the calcareous sandstones above the huge 26-foot bed, I discovered a magnificent series of fossil leaves, among which, Dr. Newberry informed me, he had detected species identical with those occurring in connection with the coal beds of the Laramie Plains, and on the Upper Missouri. No plants have been observed in the vicinity of Bear River City. What relation the coal beds here sustain to those at Evanston, I cannot determine. As yet there is no evidence of any connection whatever, except proximity.

The next locality where coal is exposed is at Coalville, a little town in the valley of Weber River, five miles above the mouth of Echo Creek, where it crops out in a number of places over a very restricted area. The general dip of the beds is northwest, 10° to 18°. The most important opening of a coal vein is that of Mr. Spriggs. The coal bed is fifteen feet thick, twelve feet of good coal, and the other three feet somewhat impure, but useful as a fuel. The dip is 20° to 30°; the roof is composed of yellowish-gray sandstone, sometimes a pudding-stone, with only about an inch or so of clay between. An air shaft sunk by Mr. Spriggs passed through the sandstone sixty feet. Mr. Spriggs informed me that there were six different seams of coal in this region. Just above the third seam there is a layer of oyster shells about four feet thick; the clay under the coal varies in thickness, sometimes sixteen feet, again eighteen inches; below this is a yellowish-gray or brown sandstone. Looking down the Weber Valley, the group of beds form a sort of semicircle, dipping west and northwest. In the high ridge that lies immediately north of Chalk Creek, we have a series of yellowish and brown-gray clays and sands, with one or two beds of light, brick-red, arenaceous clay, the whole extending up two hundred and fifty feet above the coal, apparently. On the summit of this ridge, and in different layers along the outcropping edges of the ridge, are great quantities of marine shells, which are regarded as of very modern cretaceous types. A few hundred feet south of Spriggs's opening, a party sunk a shaft eighty feet with the intention of cutting the bed of coal; the shaft cut through the black clays of what I regard as cretaceous No. 4. In the clays that were thrown out of the shaft were great quantities of *Inoceramus*, *Ammonites*, *Ostrea*, &c. The coal is evidently in close proximity to these cretaceous clays, but, I think, above them. From Chalk Creek to Echo City it is about four miles in a straight line; about two and a half miles of it is occupied by eight to twelve ridges of the coal strata, inclining 10° to 30°, averaging 20°. There is not less than one thousand feet of them exposed here, but the coal is mostly, and perhaps all the workable beds are, in the lower portion. There is a sort of valley which forms the line of separation between the coal strata and the Wasatch Group; the remaining one and a half miles is composed of the Wasatch conglomerates. In the group of coal strata, all of which I suppose lie above the Coalville bed, shells of the genera *Anchura*, *Gyrodes*, *Inoceramus*, and *Ostrea*, are found. The evidence seems to point to the cretaceous age of the coal group in Weber Valley. It is the only locality in the West that has come under my observation where the proofs seem to be so conclusive; and yet I wish to make a still more careful examination of this locality before I commit myself fully. My reading of the rocks is, that they are either upper cretaceous, above what we have usually regarded as No. 5, or a portion of my transition series, more purely marine in their character than usual.

If it is true that there must have been such a continuity in the progress of events during geological times that there can be no general physical line of separation between any of the great periods, and that the names Jurassic, cretaceous, or tertiary are merely terms of convenience—milestones, as it were, to mark steps of time—then why should not certain marine forms of life extend up into the lower eocene, or in other words, did not the cretaceous deposits at certain localities continue on up, unchanged, into tertiary time? Whether the coal strata of the West are of cretaceous or tertiary age, or both, is a matter of indifference to me; I only wish to discuss the subject from time to time, as the occasion offers, in the light of such facts as I can secure. The geologist is simply the interpreter of nature. He must seek to read the records as the Creator has written them upon the tablets of stone, and his observations will be of permanent value only when he is able to arrive at the true reading. Experience has shown that with a simple love of the truth, untrammeled by tradition or preconceived notions one is led step by step, slowly, perhaps, and through many difficulties, but eventually, to the light.

We will now pass rapidly down the valley of the Weber River. The geological structure is very complicated, and there is much that is yet obscure. We only hope, at present, to contribute something toward a knowledge of it. Every year we hope to gather more facts and extend our examinations over larger areas. Before proceeding further we might say a word in regard to the conglomerates which form the most conspicuous feature in the geology of this region. I now regard the whole group as distinct from any other—a separate lake basin. The eastern shore of it may be regarded as the same as the eastern rim of the great basin, of which Salt Lake Valley forms a part. The great thickness of variegated clays, sands, and sandstones, which we see from Carter Station to the middle of Echo Cañon, lie beneath the vast body of conglomerates in Echo and Weber Valleys. I have never been able to find a single well-defined fossil in this group, only a few small fragments of the shell of a fresh-water turtle. It occupies so large an area that it seems to me more careful explorations must bring to light some organic remains. From physical evidence I am inclined to the belief that it began its existence after that of the Green River Group, but before the close of that period and extending up through the time of the deposition of the Bridger Group; that is, the conglomerates are probably on a parallel with the Bridger Group, or upper miocene. These conglomerates originally extended entirely across the Wasatch Mountains. In City Creek Cañon, on the west side of the range, these conglomerates are finely shown, a thousand feet or more in thickness, inclining from the range. There is the same evidence of want of conformity as is shown near the "Narrows," but no rocks more recent than the Jurassic limestones were observed between them. I do not doubt that further to the southward both cretaceous and older tertiary beds occur on the flanks of the mountains. The immense thickness of strata exposed in the Weber Valley seems to be made up, so far as I can ascertain, of Jurassic, triassic, and carboniferous rocks. Near Morgan Station, in limestones which appear to hold a position at the base of the series, I saw great quantities of fossils, among them several varieties of *Productus*, *Spirifer*, &c., well-known carboniferous forms. Fossils of the same age are quite abundant just over the range near Salt Lake City, and in many other localities all over the valley. There may be restricted areas in the Salt Lake basin where unchanged rocks of older date than the carboniferous occur, but they have so far escaped my observation, and we have no evidence of their existence from the examinations of other explorers.

In my last preliminary report I alluded briefly to a series of sands, sandstones, marls, &c., in the Weber Valley, between Morgan Station and Devil's Gate, and also along the foot of the mountains in Salt Lake Valley proper. That they form a separate group from all others I do not doubt, although in point of time they may be regarded as an extension upward of the Wasatch Group. I have given these the name of the Salt Lake Group, and I believe them to be of pliocene age. All through the mountain districts these later pliocene deposits occur, composed of light-colored clays, sands, marls, &c., not unfrequently yielding numbers of vertebrate remains. The Salt Lake Group has so far revealed but few fossils, only one species of Helix. During the middle tertiary period, it seems probable that the metamorphic and granitic rocks which form the nucleus of the mountain ranges were exposed to the erosive action of the waters to a great extent, and thus their decomposition, mostly feldspar, supplied the materials for these pliocene deposits. Their uniformity in composition and color is quite remarkable. In most cases these beds have been very slightly disturbed and do not conform to the older rocks, though I think they conform to the conglomerates. These recent beds underlie the benches or terraces which form so marked a feature in Salt Lake Valley. There are still more recent deposits in Salt Lake Valley, which, from their magnitude, deserve mention. As we emerge from the Weber Cañon into Salt Lake Valley we see on either hand high, rounded hills, which jut close up to the foot of the mountains. All the older rocks seem to have been swept away, leaving a very large area, from a point about ten miles north of Salt Lake City to the mouth of Bear River, occupied only by the arenaceous clays of the quarternary period. The cuts along the railroad show the character of these deposits quite clearly. Still more recent, and probably forming a portion of this deposit, are the immense accumulations of loose sands and drift or worn pebbles and boulders which are found everywhere in Salt Lake Valley and extend high up the valleys of the streams which empty their waters into Salt Lake. From the mouth of Echo Creek to the Salt Lake Valley, Weber Valley is covered with a prodigious quantity of worn rocks of greater or less size, from a small pebble to boulders two or three feet in diameter. The terraces are composed of fine sediments, mingled with pebbles and boulders. On the sides of the Weber River, in its passage through the Wasatch range, we see fifty to one hundred feet of this fine sand, gravel, and boulders, with a kind of irregular stratification, which indicates deposition in moving waters. I mention these details to show with what fidelity the records of the various changes, geographical and geological, of this valley, have been preserved. We see that by careful examination we can trace the history step by step far back, from the middle of the tertiary period up to the present time.

Let us for a moment glance at some of these intermediate steps and ascertain what bearing they have on the progress of the growth of our continent. The Salt Lake Group, which I have already described, I regard as an important feature in the history.

The sediments reach a thickness of eight hundred to one thousand two hundred feet at least. It not only occupied a vast area in the great basin, but extended up the valleys of the numerous rivers that flow therein. In the Weber Valley above the Devil's Gate, or on the east side of the Wasatch range, this group occupies an oval area of twelve miles long and eight miles wide, or about one hundred square miles. It forms one of the series of mountain lakes which occupied hundreds of the oval areas, or parks as they are now called, in the great mountain system which extends from the Arctic on the north to the Isthmus of Darien on the south, and I presume also to Patagonia, in South America.

The Salt Lake Group I regard as of pliocene age and contemporaneous with the Niobrara, Arkansas, and Santa Fé Groups, with numerous other small accumulations of marls and sands in the Middle Park, and among the mountains far to the northward and throughout the Humboldt Valley, Oregon, &c. All the proofs we can secure, up to the present time, indicate their fresh-water origin. What geographical changes have occurred in this long period of time we will not now attempt to determine; we wish simply to express our belief that, at least since the middle tertiary period, the salt ocean has not had access to this great basin. If now we pass to what may be called for convenience the quartenary period, or the one that gradually merges into the present, we shall find that it presents geological features of no ordinary interest. In descending the Weber Valley, after we emerge from the cañon of the Wasatch range into the open valley of Salt Lake, we observe on either side thick beds of sands and arenaceous clays, which must have been deposited in the quiet waters of a lake.

In the valley of Salt Lake, and especially in that of the Weber River, these drift deposits possess a thickness of several hundred feet, and of these materials the terraces are formed. Near Salt Lake City, in digging a well, fresh-water shells were found in these deposits, forty feet below the surface, and on the north side of the lake, where these deposits are very largely exhibited, the cuts in the railroad, through the gravel and sands, reveal the greatest abundance of fresh-water shells, showing that at this time the physical conditions were unusually favorable for the existence of fresh-water molluscous life. So far as I could ascertain, these conditions do not exist at the present time, or if they do, it must be only to a limited extent.

I am indebted to the kindness of Mr. George W. Tryon, jr., for the identification of the species obtained from this drift:

1. *Fluminicola fusca.* This species seems to have been very abundant; it exists at the present time in the mountain streams.
2. *Pomatiopsis Cincinnatiensis.*
3. *Amnicola limosa.*
4. *Valvata sincera.*
5. *Limnea desidiosa.*
6. *Limnea catiscopium.*

From these observations I infer that a vast fresh-water lake once occupied all this immense basin; that the smaller ranges of mountains were scattered over it as isolated islands, their summits projecting above the surface; that the waters have gradually and slowly passed away by evaporation, and the terraces are left to reveal certain oscillations of level and the steps of progress toward the present order of things; and that the briny waters have concentrated in those lake basins, which have no outlet. The entire country seems to be full of salt springs, which have, in all probability, contributed a great share to the saline character of the waters.

But we must not omit to mention in this connection the Warm Springs, which are located about a mile north of the city. They issue from the limestone rocks near the foot of the mountains; all around the place are tufa-like incrustations of sufficient hardness to be used for walls and fences. The baths at this place are the most grateful I have ever enjoyed, and I cannot well conceive of a more desirable locality for invalids in a sanitary point of view. The following analysis of the water, made by Dr. Charles S. Jackson, of Boston, is posted on the walls of the bathing-house, which any one can have the privilege of reading or copying:

Three fluid ounces of the water, on evaporating to entire dryness in a platina capsule, gave 8.25 grains of solid dry saline matter:

Carbonate of lime and magnesia	0.240	1.280
Peroxide of iron	0.040	0.208
Lime	0.545	2.907
Chlorine	3.454	18.421
Soda	2.877	15.344
Magnesia	0.370	2.073
Sulphuric acid	0.703	3.748
	8.229	43.981

It is slightly charged with hydro-sulphuric acid gas and with carbonic acid gas, and is a pleasant, saline mineral water, having the valuable properties belonging to saline sulphur springs.

The above is a true copy of the analysis, and the reader can extract for himself whatever information of value it may contain.

About three miles north of the city are the Hot Springs, which are well worth the examination of the traveler. The water boils up from beneath beds of limestone at the base of the mountains, and it is only necessary to thrust the hand into it to ascertain that it is boiling hot. Meat is readily cooked in it, and eggs will be ready for the table in three minutes. The dense column of steam that rises perpetually will always point out the locality of the springs. Quite a large volume of water issues forth, forming a stream four or five feet in width and six inches in depth. It flows into a beautiful lake not far distant to the west, called Hot Spring Lake. This lake is supposed to be supplied to some extent with water from hot springs beneath the surface. Still the hot water is not sufficient to prevent the existence of some kinds of excellent fish, among them fine large trout. Springs which, if they existed on the Atlantic coast, would be of great value, are so common throughout all this region that they attract but little attention. Hot, warm, and cold springs frequently issue from the ground only a few yards apart.

In no portion of the inland West will the traveler so delight to linger and enjoy the novelty and beauty of the scenery and the exhilarating influence of the atmosphere. But before leaving this pleasant region we may devote a paragraph at least to the remarkable inland sea which gives the name and fame to Central Utah.

Although such streams as the Jordan, Weber, and Bear Rivers, with numerous smaller ones, have been for ages pouring a vast volume of water into this lake, it is now well known that it has no visible outlet; the question naturally arises, What becomes of all the water thus gathered into this area? We believe that it all disappears by evaporation. It seems, however, that of later years the evaporation has not been going on as rapidly as in former times. It is stated by the railroad engineers that the waters of the lake have risen nine vertical feet since 1864, and the general impression is, that all the lakes of the West are rising more or less.

We might note, in this connection, many changes which this valley must have been subjected to since the present configuration of the surface was outlined by the elevation of the mountain chains. Several times this valley must have been filled high up on the mountain sides with water; water, too, with but very little of that saline character which it possesses at this time. Indeed, I am convinced that, while the lake itself is not of modern origin, yet as a salt lake, in its present condition, it is of comparatively recent date. We find all along the flanks of the mountains, and high up in the valleys of the ravines opening into this basin, groups of strata hundreds of feet in thickness, which are doubtless of fresh-water origin, dating back into the pliocene or upper tertiary period. Then these beds have been disturbed by the elevations of the mountains, showing that while these ranges formed shore lines for the lakes of this period, they did not reach their present height until after the deposition of these tertiary beds. Resting upon them, and apparently deposited after the upheaval movements had ceased, are heavy beds of sand and gravel, and the flanks of the mountains all around the valley, as well as the sides of the mountains in the islands of the lake, reveal numerous water lines, showing most clearly the elevations to which the waters of the lake must have reached in later geological times. We can hardly suppose that during these periods the waters here were sufficiently salt to differ from the other lakes in the West. I am inclined to the belief, therefore, that the saline materials of a vast area have been concentrated by time into the basin now occupied by Salt Lake, and that it is owing to its partial evaporation that its water is become so salt.

Let us for a moment take a bird's-eye view of the great inland basin of which Salt Lake Valley forms only a part. We shall find that what is termed the Great Basin of the West comprises the vast area inclosed by the Wasatch Mountains on the east, and the Sierra Nevada on the west, the crest or water divide of the Columbia on the north, and that of the Colorado on the south. We shall also observe that this great region has no visible outlet; that it is composed of a multitude of smaller basins or valleys, each of which has its little lakes, springs, and water-courses, their surplus water either evaporating or sinking beneath the surface. If we examine the elevations in this region, we observe a wonderful uniformity in the surface of the valleys, and find that none of them are much above the level of the waters of Great Salt Lake. As Captain Stansbury has remarked:

> These plains are but little elevated above the present level of the lake, and have, beyond question, at one time formed a part of it; an elevation of but a few feet above the present level of the lake would float this entire flat to a great distance, thus forming a vast inland sea.

It seems probable, also, that at a comparatively modern period the briny waters spread out over a much larger area than at present, for both Frémont and Stansbury make frequent mention of large tracts covered with an incrustation of salt. The latter, in describing the broad plain country to the west of Great Salt Lake, says:

> The first part of the plain consisted simply of dried mud, with small crystals of salt scattered thickly over the surface. Crossing this, we came upon another portion of it, three miles in width, where the ground was entirely covered with a thin layer of salt in a state of deliquescence, and of so soft a consistence that the feet of our mules sank at every step into the mud beneath. But we soon came upon a portion of the plain where the salt lay in a solid state in one unbroken sheet, extending, apparently, to its western border. So firm and strong was this unique and snowy floor, that it sustained the weight of our entire train without in the least giving way or cracking beneath the pressure. Our mules walked upon it as upon a sheet of solid ice. The whole field was crossed by a network of little ridges, projecting about half an inch, as if the salt had expanded in the process of crystalization. I estimated this field to be at least seven

miles wide and ten miles in length. How much farther it extended northward I could not tell, but if it covered the plain in that direction as it did where we crossed, its extent must have been very much greater. The salt, which was very pure and white, averaged from one-half to three-fourths of an inch in thickness, and was equal in all respects to our finest specimens for table use. Assuming these data, the quantity that here lay upon the ground in one body, exclusive of that in a deliquescent state, amounted to over four and a half millions of cubic yards, or about one hundred millions of bushels.

Areas of greater or less extent, covered with this saline incrustation, occur in numerous localities, so that we may infer that in all probability, at no very distant period in the past the salt lake extended either connectedly, or in isolated portions, over the greater part of the Great Basin.

It would be a most interesting subject to trace the history of this wonderful lake far back in the geological past; from the records which have been left in the sediments, I have obtained comparatively few facts as yet, but they seem to be quite conclusive, and I believe that each successive step in the changes which this great region has undergone can be interpreted with accuracy from the records left in the surface deposits, if they could be studied in detail.

One of the most conspicuous features in this basin, is the system of terraces or benches which borders the valleys as well as the streams. These terraces seem to form an independent system in this basin, disconnected, both in regard to time and the causes that produce them, from those so well known along the Missouri and Columbia Rivers.

Not only do they seem to be universal over this great basin, but they are all of about the same level. I have never observed more than two or three of these benches well defined, but Captain Stansbury speaks of counting thirteen successive terraces at the northern end of the lake, the highest about two hundred feet above the valley.

In volume II of the Pacific Railroad Reports, page 97, there is a most interesting note in regard to these remarkable shore lines, which I am sure will be as instructive to those who may read this volume as it has been to me:

The old shore lines existing in the vicinity of the Great Salt Lake present an interesting study. Some of them are elevated but a few feet (from five to twenty) above the present level of the lake, and are as distinct and well defined as its present beaches, whilst their magnitude and smoothly-worn forms as unmistakably indicate the levels which the waters maintained at their respective formations for very considerable periods. In the Tuilla Valley, at the south end of the lake, they are so remarkably distinct and peculiar in form and position that they attracted the attention of the least-informed teamsters of my party, to whom they appeared artificial. From these beaches the Tuilla Valley ascends gradually toward the south, and in a few miles becomes blocked up by a cross range of mountains, with passages at either side, leading, however, over quite as remarkable beaches, into what is known to the Mormons as Rush Valley, in which there are still small lakes or ponds, once doubtless forming part of the Great Salt Lake.

The recessions of the waters of the lake from the beaches at these comparatively slight elevations must have taken place within a very modern geological period, and the volume of the water of the lake at each subsidence—by whatever cause produced, whether gradual or spasmodic—seems as plainly to have been diminished; for its present volume is not sufficient to form a lake of even two or three feet in depth over the area indicated by these shores, and, if existing, would be annually dried up during the summer.

These banks are not peculiar to the vicinity of this lake of the basin, but were observed near the lakes in Franklin Valley, and will probably be found near other lakes, and in the numerous small basins which, united, form the Great Basin. They clearly seem to have been formed and left dry within a period so recent that it would seem impossible for the waters which formed them to have escaped into the sea, either by great convulsions opening passages for them, or by the gradual breaking up of the distant shore, (rim of the basin,) thus draining them off, without leaving abundant records of the escaping waters, as legible at least as the old shores they formed.

But high above these diminutive banks of recent date are seen, on the mountains to the east, south, and west, and on the islands of Great Salt Lake, formations preserving apparently a uniform elevation as far as the eye can extend—formations which, hastily examined, seem no less unmistakably than the former to indicate their shore origin. They are elevated from two hundred or three hundred to six hundred or eight hundred feet above the present lake, and may on careful examination afford the means of determining the character of the sea by which they were formed, whether an internal one, subsequently drained off by the breaking or wearing away of the rim of the basin, or an arm of the main sea, which with the continent has been elevated to its present position and drained by the successive steps indicated by these shores.

These terraces seem to be a marked feature of the valleys of streams on both sides of the Rocky Mountains. In the valleys of the Missouri River and its tributaries, even the smallest branch, they are to be seen more or less conspicuous. Professor Dana describes them with much care, as universal on the Pacific coast. So far as those terraces are concerned which occur on the Pacific coast and the eastern slope of the Rocky Mountains, I believe they have a common origin; but the terraces of this great inland basin might be synchronous or quite independent of the others. Still, as both must have been formed near the close of the quarternary period, constituting the last act in the drama, we might consider them all as having a common origin. If we were to examine the whole country west of the Mississippi, the broad plains of the eastern slope rising gradually to the foot of the mountains and to the very summits of the loftiest ranges, descend into the plains on the opposite side, and explore the valleys of the inland streams, the parks and basins, we shall find everywhere, to a greater or lesser extent, the proofs of a very modern drift deposit, or that among the latest events in the geographical history of our continent is the evidence that it was nearly or quite submerged with water. Some of the highest peaks may have projected above the almost universal sea of waters; but the tops of the highest mountains, as the Wind River, Big Horn, Uinta, show the drift boulders at an elevation of twelve thousand feet above the sea. So far as my own observations are concerned, all the evidences I have been able to detect show that the superficial or quarternary deposits of the West are of local origin. In the vicinity of the mountain ranges the proofs of the origin of the vast mass of the boulder drift is very apparent. The hills at the base of the mountains are often covered with masses of rocks, usually but slightly worn. And as we recede from the mountains these rocks become smaller and more worn, until far out in the plains they are reduced to mere pebbles. But it is in the inland plains and parks, as Laramie Plains, the Great Salt Lake Basin, North, Middle, and South Parks, &c., that the greatest exhibition of this local drift action is best shown. In the Missouri Valley, and especially north in Minnesota and Dakota, these stray masses are scattered in the greatest profusion all over the surface of those broad, treeless plains. The character of the rocks themselves shows that they came from the mountains. Sometimes these rocks are strewn in belts across the country, taking a uniform direction. North of the Missouri River, from the Big Sioux River to Fort Clark, there are districts where one might walk for miles across the plains and over the hills without stepping upon the ground, so closely paved is it with worn or partially-worn boulders. The celebrated Coteau de Prairie was no doubt outlined by these drift forces, and scattered over the hills are masses of these rocks. The accompanying figure 17 will convey an idea of a strip of country which forms a sort of water divide between the drainage of the Missouri, Mississippi, and the Red River of the North.

As we have previously remarked, we believe that the quaternary period, although more difficult to study, will be found to be scarcely second in importance to any of the previous great epochs in geology.

A careful study of these modern deposits will undoubtedly show consecutive links by which it was united to the tertiary period, in the same manner as the cretaceous and tertiary are connected in the case of

Fig. 17.

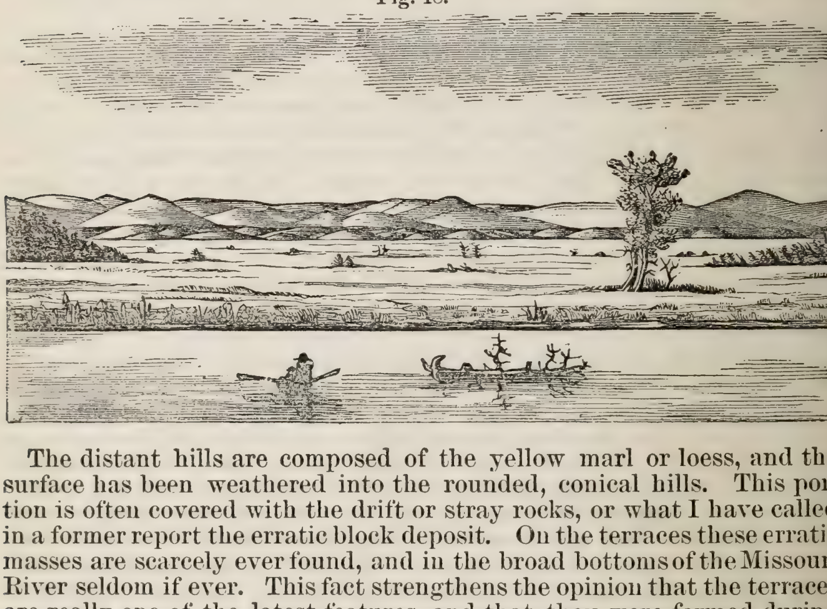
Coteau des Prairies, on the Missouri.

the great tertiary lake now indicated by the deposits on White and Niobrara Rivers, in Nebraska, in which the waters continued to cover a greater or less area through most of the quaternary period, at least, as is shown by the thick deposits of fine sand, with bones of mammals and shells of existing species, on Loup Fork and its tributaries. The same may be said of the bluff deposit, or loess, which is so well displayed along the Missouri from Fort Pierre down below St. Louis, and, probably, to the Gulf of Mexico. At a modern period it is probable that the waters of the ocean swept high up inland, reaching nearly to the foot of the mountains. The great water-courses had already been marked out, consequently we find the yellow marl or loess fifty to one hundred and fifty feet thick in the immediate valley of the Missouri, but thinning out as we recede from it, or the valleys of any of its branches. The existence of so many fresh-water mollusca and the entire absence of any marine forms indicate that the waters of the Mississippi and Missouri were either cut off from the direct access to the sea, or that the influx of such a vast quantity of fresh water as must have flowed down from the mountain districts rendered completely fresh the inland portions.

We may suppose the temperature just prior to the present period to have been extremely low, and that the elevated portions of the West were covered with vast masses of snow and ice; that as the temperature became warmer this snow and ice melted, producing such an accession to the already existing waters that they covered all the country, excepting, perhaps, the summits of the highest peaks; that masses of ice filled with fragments of rocks, worn and unworn, floated off into this great sea, and melting, scattered the contents over the hills and plains below; that as the waters diminished these masses of ice would accumulate on the summits of the foot-hills of the mountains, or at certain localities in the plains; and thus account for the great local accumulations of stray rocks at certain places. The materials, also, which must have been removed from all portions of the West drained by the Missouri and its tributaries by surface denudation, as is illustrated by the "bad lands," &c., were also swept into this vast inland lake, and then, carried beyond the reach of currents, would settle quietly to the bottom, almost without lines of stratification, as we observe in the loess. The last act was the recession of these waters to their present position, and the formation of the terraces. We believe the terraces constitute the last change of any importance in the surface of the western continent. We suppose that the channels of all the streams on the eastern slope of the Rocky Mountains were at one time occupied with water from hill to hill, and that the drainage was toward the sea. But in the Great Basin, which, so far as we know, has no outlet, the drainage must have been by evaporation, for the evidence points to the conclusion that it was entirely filled with water high up on the sides of the mountains. There is greater uniformity in the terraces in the Great Basin than in the valley of the Missouri, which indicates a far more equable drainage. Still, those along the flanks of the Wasatch Mountains number two or three principal ones, but these formations separate into five or six; and Stansbury mentions one locality where there are ten or twelve of them. In the Missouri Valley, and along the eastern slope generally, the terraces vary much in height and importance.

Fig. 18 shows the peculiar form of the main terrace as shown on the Missouri River, just above Omaha.

Fig. 18.



The distant hills are composed of the yellow marl or loess, and the surface has been weathered into the rounded, conical hills. This portion is often covered with the drift or stray rocks, or what I have called in a former report the erratic block deposit. On the terraces these erratic masses are scarcely ever found, and in the broad bottoms of the Missouri River seldom if ever. This fact strengthens the opinion that the terraces are really one of the latest features, and that they were formed during the drainage of the waters toward the sea after the temperature had reached nearly its present state. Oscillations of level may have contributed somewhat to the formation of the terraces, but I am inclined to believe that the drainage or the contraction of the waters is the main cause. This is an important point, and I hope hereafter to treat it more fully when I have accumulated a greater number of facts. It has been my belief for years, that not only the Missouri River, but all the branches, from the largest river, like the Yellowstone or Platte, that flowed into it, to the smallest creek, that has cut its cañon deep into the sides of the mountains, were once filled with water from side to side, but have gradually shrunk to their present diminutive proportions. All over the West are large, dry beds which must have at one time given passage to vast bodies of water. The flanks of the mountains, from the north line to Mexico, are gashed with gullies or cañons, many of which are now dry as the dusty road for the greater portion of the year. I mention some of these details here simply to show how closely the story of the physical growth of our western continent is linked together, and that it needs only the careful, conscientious grouping together of the facts to secure this history step by step from the earliest commencement to the present time, and mold it into one harmonious whole.

CHAPTER XIV.

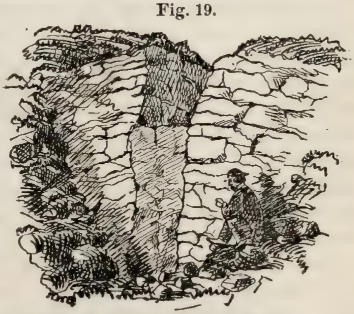
OBSERVATIONS ON MINES—ANALYSES OF COALS, ORES, AND SALTS.

Although many valuable observations have been made in regard to the gold and silver mines of the West, I shall not attempt to present them in detail at this time. The elaborate and elegantly illustrated "Report on Mining Industry," prepared under the direction of Mr. Clarence King, United States geologist of the 40th parallel, about to be issued from the Public Printing Office, covers this ground far more efficiently than my incidental labors could do. Mr. R. W. Raymond is making a series of valuable reports as United States Commissioner of Mining Statistics, and the one already published for the years 1869-'70 is quite exhaustive, and to these works the reader is referred. The latter report contains an excellent and lengthy statement of the condition of the mines of the Sweetwater district. In the preceding pages some information is given in regard to those mines, and in this chapter a few additional notes, taken by Mr. A. L. Ford, mineralogist of the survey, will be of interest.

The object of this survey is to study the mineral regions more in reference to their geological relations than with any special practical end in view.

In a previous report the remarkable parallelism of the lodes was alluded to, and an attempt was made to show that this fact is only one link in a chain of facts which may yet serve to unite the physical history of the mountain regions of the West together. Hundreds of observations were taken the past season, which serve to show the definite direction of the two principal sets of fissures or clefts. The unity of the origin of all these fissures, whether they assume the form of mineral lodes, dikes, or lines of fracture of mountain ranges, is a thought around which I wish to cluster all the facts that can be secured. Hereafter all these observations will be carefully sifted, and those which seem to contain the elements of truth will be found valuable.

Fig. 19.



Gregory Lode, Central City, COLORADO.

In this connection, two illustrations of these fissures may be introduced, which will be of interest. They are made by the Jewett line relief process, and are very excellent. One of them presents a fine section of the well-known Gregory lode at Central City. This fissure has a strike about northeast and southwest. The country rock is true gneiss, while the gangue of the lode is mostly feldspar and quartz. So far as the history of its mineral contents is concerned, it is so well known that I need not describe it, and the cut will explain itself.

The dike is in the same mountain, not more than three hundred yards from the Gregory lode. It is exposed by an artificial cut for a road up the side of the mountain, and but for this circumstance would not have been visible from the surface. It is vertical, twenty feet high, and three to four feet wide. The materials inclosed in the dike are evidently very old basalt, yellow buff color, with cavities filled with decomposed feldspar. The country rock does not appear to have suffered changes, but the lines of bedding are entirely interrupted, and curved upward.

Fig. 20.

Dyke, near Central City, *COLORADO.*

The following notes on the Sweetwater Mines were taken by Mr. Arthur L. Ford, the mineralogist of the expedition:

Cariso Mines.—Worked by Mr. Roberts, of South Pass City. Shaft one hundred and forty feet deep, sunk in vein of very refractory quartzite averaging four and one-half feet in thickness; strike of vein northwest and southeast, with dip of 70° to northeast. Cap rock and wall rock consist of tough gneissoid slate containing a little free gold, and occasionally showing a few small cubes of iron pyrites. The gold containing the quartz is very finely disseminated, but is "free" and very pure, and hence easily amalgamated; it contains about one-half ounce of silver. About four tons of ore are being taken out daily, with an average yield of $75 per ton, and sometimes doubling that amount. The quartz is of remarkably even quality, seldom falling much below the average yield. Mr. Roberts estimates the gold already produced to amount to about $75,000. The mine makes very little water, about eight or ten buckets being taken out hourly.

Young America Mine—Mr. Incath, manager. On same lode as the Cariso; quartz contains considerable disseminated oxide of iron, but is not on that account less refractory. Ore averages about $23 per ton—not visited.

East End Mine—On Miner's Delight lode, Mr. A. C. Hasey, manager. Shaft sunk sixty feet, through slightly laminated, easily-worked quartz of varying color, that having a clear blue tinge supposed to be the best, especially if breaking easily into lamina of from one to one and one-half inches in thickness. Strike of vein northwest and southeast, with dip nearly perpendicular. Vein, like the Cariso, conforms with the gneissoid slates which form the wall rock, and which are supplanted toward the surface by a porphyritic gneiss holding small quantities of gold and overlying the vein, though not forming a true cap rock. Very small traces of pyrites are contained in both wall rock and quartz. All gold, however, seems to be full. Seven tons per day of ore were being taken out by hand labor, ore averaging $20 per ton. Gold not so pure as that of Cariso, though very bright and easily amalgamated. A great deal of the gold is in flakes of considerable size, especially between the lamina of the quartz. The quartz is so soft that no blasting is needed. A good deal of moss agate occurs in the vein, noticeable when the quartz is clear.

Miner's Delight Mine—Just west of preceding; the claims join. Lode is the same, but pinches to an average width of two feet. Vein stopped down eighty-five feet, ore averaging $35 per ton. Mine not in operation at present, as buildings and machinery are in course of erection. The superintendent expects to take out fifteen tons per day.

Young Canadian Mine—One-quarter of a mile west of the preceding. Shaft sunk eighty feet through barren lode before reaching pay streak, which was struck only two or three days before the mine was visited. The ore had not been assayed, but was pronounced by all miners in the vicinity to far exceed in richness any ore yet discovered in the neighborhood.

THE COALS OF THE ROCKY MOUNTAINS.*

The coals of the portion of our continent lying west of the Missouri River are only just beginning to attract that attention which their importance deserves. In the works heretofore published on the coal-fields of the United States, they have been almost neglected, and even in Dana's last compendious work on mineralogy, he disposes of them with the remark that "tertiary coal occurs on the Cowlitz in Oregon and in many places on the eastern slopes of the Rocky Mountains, where a 'lignite formation' is very widely distributed; but it is rarely in beds of economical importance." In his enumeration of the coal-fields of the United States he mentions the Appalachian, the Illinois, the Rhode Island, and the Michigan basins. To the former two he accords an area of one hundred and twenty thousand square miles; to the latter five thousand square miles; while the area of the Rhode Island basin is left out of the account altogether; the total coal area of the United States being given as about one hundred and twenty-five thousand square miles. But besides these four basins there are the Eastern and Middle Rocky Mountain, the Monte Diablo, and the Oregon and Alaska beds to be considered. Those beds which occur on the east flank of the Rocky Mountains have been *followed* for five hundred miles and more, north and south; and if it be true that these are "fragments of one great basin, interrupted here and there by the upheaval of mountain chains, or concealed by the deposition of newer formations,"† then their extension east and west, or from the eastern range of the Rocky Mountains or Black Hills to Weber Cañon, where an excellent coal is mined, will fall but little short of five hundred miles. Throughout this extent these beds of coal are found between the upper cretaceous and lower tertiary, (or in the *transition* beds of Hayden,) wherever these transition beds occur, whether on the extreme flanks or in the valleys and parks between the numerous mountain ranges. Assuming that the eroding agencies together have cut off one-half of the coal from this area, and taking one-half of the remainder as their average longitudinal extent, we have over fifty thousand square miles of coal-lands, accounting the latitudinal extent as only five hundred miles; whereas we have no reason to believe that it terminates within these bounds, but on the contrary good reason for supposing that it extends northward far into Canada and southward with the Cordilleras. All this territory has been omitted in the estimate of the extent of our coal-fields.

Classification of coals.

The best classification of the coals is that of Professor Rogers in the second volume of his report on the geology of Pennsylvania.

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* By Persifor Frazier, jr.

† Hayden's Report on Geology of Colorado and New Mexico.

The basis of this division is partly chemical and partly structural. the genera being derived from differences in chemical constitution, while the species are made with reference to the physical properties of the coals. Thus he separates all coals into—

I. { 1. Anthracites containing 2 to 10 per cent. of gaseous matter, of which 1 to 2 per cent. is water; ash in any ratio; specific gravity 1.50.
2. Semi-anthracites containing 7 to 8 per cent. of volatile combustible matter; does not intumesce. }

II. { 1. Bituminous; carbon, 52 to 84 per cent.; volatile substances 16 to 48 per cent.; ash, 2 to 20 per cent.; specific gravity, 1.269.
2. Semi-bituminous; volatile substances more than 11 to 12 per cent. and less than 18 per cent. }

III. { Hydrogenous; volatile substances, 30 to 70 per cent.; specific gravity, 1.272. }

These varieties are further split up, in the case of bituminous, into 1*a*, caking coal; 1*b*, cherry coal; and 1*c*, splint coal. The semi-bituminous into 2*a*, semi-bituminous cherry coal; and 2*b*, semi-bituminous splint coal. The hydrogenous, 1, cannel coals; 2, hydrogenous shaly coals, (Torbanehill, &c.;) and, 3, asphaltic coal, (Albert mine.)

This classification takes no account of the age of the coals, but merely considers the nature of the mineral. Accordingly it will be found convenient of application to coals about whose age there is yet some difference of opinion among geologists.

Mode of occurrence.

The coal of the Rocky Mountains is distributed along their flanks as several leaves in the great book of folded strata and invariably in the transition beds or between the tertiary and cretaceous. Nowhere in the world is there such a vast development of the recent coal measures, and in few places is their existence more necessary to the advancement and improvement of the region in which they occur. They lie regularly and in the main quite horizontally, though close to the mountain the beds are naturally tilted. The coals are called variously lignites, brown, semi-bituminous and bituminous, though from their chemical constitution they ally themselves much more nearly with the latter. They are distinguished by their cleavage planes, which latter are nearly perpendicular to the planes of lamination and to each other, and give to the coal (which is usually friable) a stair form structure, almost resembling the crystallization of some clusters of iron pyrites. It is hardly worth while to say that these coals differ in different localities as to general structure and chemical composition.

It would be an exceedingly interesting piece of work to follow up those beds from their easternmost outcrop westward and to seek to identify them in their different plications. Paleontologically these coals, containing almost exclusively plant fossils, comparatively few shells have been discovered, and those of species which leave the real question of "cretaceous or tertiary" undecided. The great mass of the fossils are of deciduous leaves, very much resembling now existing varieties. Broad leaves like the oaks and even nuts transformed into dull red sandstone (*San Lazaro*) (in one case showing the kernel and shell beautifully distinct from each other, where a fracture of the latter had exposed the former to view) are met with in the drab clay and more especially in some dark-colored sandstones near the coal. Here, almost on the threshold of our own era, the conditions are similar in many respects to those which produced the long ago carboniferous age; the same great cretaceous sand formation ushering in the coal as the Pennsylvania No. 10 did the false coal measures and the great conglomerate the real ones. Here also we see mammoth veins and small veins, indicating a longer or shorter period of deposition or a greater or less activity in vegetable growth. Here, too, anthracites and semi-anthracites have been reported, but occupying areas much more geographically restricted than is the case in Pennsylvania. And stranger than all, here, too, are oil wells, apparently the product of this same coal age, but whose supply has trickled through the loose cretaceous and Jurassic formations and found lodgment only in the impervious triassic beds, perhaps on the granite itself. It has been stated above that these coals belong in the main to the class of the bituminous coals, both by right of their chemical constitution and their physical properties. All the specimens, from whatever quarter, which were obtained by your expedition belong to the bituminous class, so that the inference seems fair that only the middle member of the Pennsylvania series of anthracite, semi-anthracite, semi-bituminous, bituminous, and hydrogenous are represented to any extent in this portion of the Rocky Mountains. On the other hand Dr. Le Conte, in his report, mentions a true anthracite, (88 to 91 per centum of fixed carbon,) and Hollister in his "Mines of Colorado," (the mineralogical part of which was written by Mr. J. Alden Smith) speaks of albertine coal as occurring in certain parts of western Colorado. Albertine coal (or solidified petroleum, as it is sometimes improperly called) is one of the most hydrogenous coals known, and if it really exists, as Professor Denton of Massachusetts asserts it does in White River in West Colorado, the extremes and middle members of the series are to be found west of the Missouri. Still the general character of these coals is bituminous. The following are some analyses of them.

Bituminous coal from Old Placer Mines, San Lazaro Mountains, New Mexico.—This coal differs in appearance from all other coals found on the flanks of the Rocky Mountains, both in color and fracture. The former is jet black except on the conchoidal cleavage surfaces, where the half metallic bronze lustre, similar to that of the anthracites, is observable. Fracture conchoidal and uneven, splintery; specific gravity less than that of the Pennsylvania anthracites.

	Milligram.
Weight in air of specimen	338.6
Weight in water with plat wire after boiling	110.0
Weight of wire 7 milligrams, allowing for 1 milligram loss of weight of plat wire in water, 6 milligrams	104.0

338.6—104.0=234.6.
338.6÷234.6=1,443.3 specific gravity.

First analysis:

	Per cent.
Water and volatile substances	22.0
Ash	8.2
Fixed carbon	69.8
Total	100.0

Second analysis:

Water	3.0
Volatile substances	21.0
Ash	7.5
Fixed carbon	68.5
Total	100.0

Third analysis:

	Per cent.
Water	3.0
Volatile substances	22.0
Ash	7.5
Fixed carbon	67.5
Total	100.0

Fourth analysis:

Water and volatile substances	22.0
Ash	7.5
Fixed carbon	70.5
Total	100.0

Fifth analysis:

Water and volatile substances	23.0
Ash	7.5
Carbon	69.5
Total	100.0

* Sixth analysis, (F. P.:)

Water	2.25
Volatile substances	20.75
Ash	6.40
Fixed carbon	70.60
Total	100.00

Seventh analysis, (F. P.:)

Water	3.75
Volatile substances	21.25
Ash	6.00
Fixed carbon	68.00
Total	100.00

Average of seven analyses:

Water	3.00
Volatile substances	20.85
Ash	7.23
Fixed carbon	69.09
Total	100.17

Of sulphur 0.72 per cent. was obtained.

Bituminous coal from Marshall's property near Boulder City, Colorado Territory.—This coal is black, (in powder dark brown,) and when exposed to the atmosphere friable, as are all of these tertiary coals. Its fracture is conchoidal and the luster of the smooth surfaces of fracture resinous.

Specific gravity	1.412
Weight in air	595.06
Weight in water	173.08

First analysis:

	Per cent.
Water	16.00
Volatile substances	38.00
Fixed carbon	42.00
Ash	4.00
Total	100.00

* The analyses marked F. P. were made by Mr. Franklin Platt, jr.

	Per cent.
Second analysis:	
Water and volatile substances	54.00
Ash	4.00
Fixed carbon	42.00
Total	100.00
Third analysis:	
Water	16.00
Volatile substances	38.00
Ash	4.50
Fixed carbon	41.50
Total	100.00
Fourth analysis:	
Water	16.00
Volatile substances	38.00
Ash	5.00
Fixed carbon	41.00
Total	100.00
Fifth analysis:	
Water	16.00
Volatile substances	38.00
Fixed carbon	41.00
Ash	5.00
Total	100.00
Average of five analyses:	
Water	16.00
Volatile substances	38.00
Ash	4.50
Fixed carbon	41.50
Total	100.00

Bituminous coal from Spriggs's Mine, Weber Cañon, Utah Territory.

Water and volatile substances	50.80
Ash	3.60
Fixed carbon	45.60
Total	100.00

Bituminous coal from Evanstown, Union Pacific Railroad.—This coal is black, (even in powder,) has a highly resinous luster, and a fracture like the other coals of this class, irregular and conchoidal. It appears better able to resist the action of the atmosphere than the other tertiary coals examined, and is not nearly so friable. Its specific gravity is 1.341.

	Per cent.
First analysis:	
Water	6.00
Volatile substances	38.00
Ash	7.50
Fixed carbon	49.50
	100.00
Second analysis:	
Water	5.50
Volatile substances	37.00

	Per cent.
Ash	7.70
Fixed carbon	49.80
	100.00

Third analysis, F. P.:

Water	6.00
Volatile substances	37.00
Ash	7.60
Carbon	49.40
	100.00

Average of three analyses:

Water	5.83
Volatile substances	37.40
Ash	7.46
Fixed carbon	49.50
	100.19

Coal from Elko.—A lignite of light-brown color and low specific gravity, possessing the feel and much of the appearance of wood; is tough and tenacious when pounded or rubbed in a mortar. It is filled with minute specks, of metallic color and luster.

As the coal had been kept a long time in a warm room, and had therefore altered in respect to its per centage of water, this and the volatile substances were determined together.. A fresh specimen would probably contain from 7 to 10 per cent. water.

	Per cent.
Water and volatile substances	63.50
Carbon	22.00
Ash	14.50
Sulphur	0.82
	100.82

Ash is of a pure gray color, a fine dust-like powder, containing but a small percentage of soluble salts.

Iowa coals.—From specimens of coal sent by Mr. Miller, of the Omaha Herald, from Des Moines and Ottumwa, Iowa, the following analyses were made, and may be interesting to compare with those of the Rocky Mountain coals:

No. 1, (Ottumwa,) specific gravity, 1.327:

	Per cent.
Water	12.00
Volatile substances	32.00
Ash	12.00
Fixed carbon	44.00
Total	100.00

No. 2, (Des Moines:)

Water	7.0
Volatile substances	47.6
Fixed carbon	41.4
Ash	40.0
Total	100.0

Sulphur existed in both the specimens to the extent of, perhaps, 1 to 2 per cent., but was not quantitively determined.

Considerations affecting economic value of these coals.

A coal to be of value in the arts and as a domestic fuel should have certain properties which render it easy of transportation, not easily nor deleteriously affected by weather or climate; should be capable of rapid ignition, and of having its combustion regulated to suit the different circumstances attending its employment; should be capable of raising proportionately to its bulk and weight a large amount of water to the state of vapor, and should contain within itself the least quantities of such substances as by contact with the grate bars at a high heat would injure them, or whose products of combustion are poisonous to vegetation, or to animal life, or are corrosive.

It follows from some of these conditions that the coal to be of the greatest possible use must neither be crumbly nor so compact and tough as to render its oxidation difficult by permitting a comparatively small extent of coal surface to be brought in contact with the oxygen of the draught. Also, for the same reasons, it must not cake or run together so as to exclude the air from its interior parts, nor pulverize whereby much loss is sustained by the dust being carried through the flame and up the chimney without being consumed. Then the cleavage of the coal should be such that a large amount can be stored without waste of room in the interstices between the lumps, for it is evident that more material can be packed in a given space when the form of the separate pieces is somewhat regular and the surfaces are close together, than where each lump touches the neighboring lump in only a few points, leaving an unoccupied space between their surfaces. It should be hard enough to resist the grinding and pulverizing effect produced by motion as in the bins of a steamer or the tender of a locomotive. In the article on the subject in Professor Rogers's report on the geological survey of Pennsylvania, the author for many reasons leans to the belief that to the many economic purposes the semi-bituminous coals are better adapted than any others. From the blacksmith's forge and the smelting and roasting furnace to the uses of the locomotive or the kitchen, the Rocky Mountain coals have been sufficiently proved in the last few years to answer admirably all the requirements made of them. As it is not possible to obtain all these good qualities in any single fuel, (see Rogers's report,) the problem in every case is to select that which possesses the greatest number of them. For instance, for railway purposes the coal of the Real Dolores, though containing a higher percentage of fixed carbon, is less valuable than some of the semi-bituminous coals, because it is neither so easily ignited nor is its combustion so easily regulated, whereas for domestic and all other purposes where the hard dry coals are preferred it is a most excellent fuel. Those coals which disintegrate readily on exposure to the weather, (this includes most of the beds on the eastern flanks of the Rocky Mountains, and in fact the majority of the western coals everywhere,) are not so serviceable to the engine-driver (whatever their percentage of carbon may be) as others with more ash and water but also more power of resistance to atmospheric influences.

The examination of two samples of brown coal from Wyoming Territory, by the very able chemist, Dr. F. A Genth, of Philadelphia, will be useful for comparison in this connection:

1. Coal from seven miles east of Cooper Station, on the old stage road, Laramie Plains, Wyoming Territory, gave:

	Per cent.
Moisture	9.28
Volatile matter	39.12

	Per cent.
Carbon	47.04
Ash, yellowish brown	4.56
	100.00

It contains 1.38 per cent. of sulphur, which is equal to 2.59 per cent. of pyrites.

A determination of the caloric power of this coal showed a reduction 22.20 parts of lead from the oxide, by one part of coal, while pure carbon reduces 34 parts of lead.

2. Coal from Point of Rocks Station, North Pacific Railroad, Wyoming Territory, gave:

	Per cent.
Moisture	8.54
Volatile matter	30.60
Carbon	52.34
Ash, white	8.52
	100.00

It contains a very minute quantity of sulphur, only 0.04 per cent., which is equal to 0.075 per cent. pyrites. One part of this coal is capable of reducing 21.80 parts of lead from the oxide.

The following notes present the results of actual experiments on our different western coals, by Mr. Samuel Purnell, superintendent of the Omaha Gas Works. It will be seen at a glance that their practical character renders them worthy of attention. It is my wish to include in these reports all the information possible that will be likely to prove of practical interest to the West:

The results of the working of one ton of lignite, or Rocky Mountain coal, from Evanston, Utah, in the Omaha Gas Works, are as follows:

Weight of coal used, 2,000 pounds; gas made, 7,400 cubic feet; time of charges 3½ hours; tested in clay retorts, at bright orange heat, (21 90°;) candle power of the gas at the works, 7 to 8; but will not carry its carbon in the street mains, burning blue in the town; water produced from the coal, 20 gallons; tar produced, 1 gallon.

The gas possessed a most offensive sulphurous odor, which neither lime nor oxide of iron purification would remove, and which was neutral to test papers. The residue in the retorts, as coke, consisted of 12 bushels of earthy breeze, in small cubes, which, when put in the furnace fires, smothered them. The coke is worthless for heating purposes. The coal is worthless for gas purposes.

Coal from Rock Springs, Wyoming, was also tested, and it is precisely similar.

I have carefully analyzed a sample of coal taken from a bed seven inches thick, nine miles below Omaha, on the Omaha and Great Western Railroad.

	Per cent.
Volatile matter	42.62
Coke	54.88
Ash	11.00
Sulphur	00.50
	100.00

The coal is black, bituminous, and contains in small quantity sulphide of lime, sulphide of iron, and oxide of iron. The coke is good, of moderate firmness, and of bright luster. By the sujoined table of comparative analyses, the coal is found to be almost identical with the Missouri and Iowa coals.

Coal.	Volatile matter.	Coke.	Ash
Omaha	42.87	46.13	11.00
Des Moines, Iowa	44.00	47.50	8.50
Ottumwa, Iowa	44.50	44.57	10.93
Frederick, Iowa	47.67	42.33	10.00
Osage River, Missouri	43.50	51.16	5.34
Rock River, Illinois	44.50	45.50	10.00
Clarksburg, West Virginia	41.66	56.74	1.60

ALKALI FROM PUNTIA PASS.*

The word alkali is used on the Plains to indicate a saline deposit which covers often many miles of low, arid country, and appears in streaks stretching far away in all directions and sometimes giving the country the appearance of a plain covered by a sheet of snow. It is very generally believed by the inhabitants that this alkali is the cause of the sterility in connection with which it almost always occurs; but the fact is that one circumstance favors its continuance upon the soil and interferes with vegetation, and that is the want of rain. Any continuous rain would undoubtedly dissolve this material and carry it away in the streams or through the subsoil. It is not quite certain that a soil charged with the salts of which this alkali is composed would not furnish more nutriment than another to certain kinds of growth. At all events, where the experiment has been tried the plants have grown remarkably well upon it with proper treatment.

The probable origin of these deposits has been thought to be the evaporation of numerous shallow pools, perhaps left by the subsidence of a large inland sea or system of lakes, and the analogy in chemical constitution between this material and the deposit around the margins of still-existing pools (like the Soda Lake, twelve miles from Denver) seems to bear out the hypothesis.

This alkali is a grayish-white deposit, mixed up with the dry roots and stems of sage-brush and other vegetation, from which it derives frequently a reddish-brown tinge. It is dry and efflorescent.

It has a decided alkaline and salty taste and low specific gravity.

It contains soda, lime, and magnesia, sulphuric acid, hydrochloric acid, and a small quantity of nitric acid, and consists of sulphates of soda, lime, and magnesia, chloride of sodium, and nitrate of soda.

SODA FROM SODA LAKE.

(12 miles from Denver, Colorado Territory.)

A white, efflorescent salt, falling to powder on exposure to the air, containing sulphate of soda, sulphate of lime, sulphate of magnesia, and chloride of sodium.

	Per cent.
Sulphate of soda	63.87
Sulphate of lime	9.70
Water of crystalization of the efflorescence	21.88
Chloride of sodium, sulphate of magnesia., &c	4.55

†I inclose the results of the analysis of the specimens of alkali collected during last summer's survey of Wyoming Territory.

No. 1. From Alkaline Lake two miles east of Independence Rock, in the Sweetwater Valley:

	Per cent.
Sulphate of soda, ($Na\,O$, $S\,O_3$)	73.17
Chloride of sodium, (Na, Cl)	3.85
Carbonate of soda,‡ (by loss)	22.98
	100.00

* Prepared by Persifor Frazer, jr.

† Prepared by Arther L. Ford, mineralogist to the survey.

‡ Owing to this specimen's effervescing on being dissolved in water, it was impossible to determine the proportion of carbonic acid, but the salt seems to have been a sesquicarbonate, the whole specimen being probably identical with or similar to that referred to by Dana in his mineralogy, under the head of Trona, as occurring near the Sweetwater River.

No. 2. From alkaline efflorescence on damp ground, seven miles west of St. Mary's Station, in the Sweetwater Valley:

	Per cent.
Sulphate of soda, ($Na\,O$, $S\,O_3$), to	88.93
Chloride of sodium, (Na, Cl), to	11.63
	100,56

No. 3. From deposit near Pacific Springs:

	Per cent.
Sulphate of soda, ($Na\,O$, $S\,O_3$)	82.23
Chloride of sodium, (Na, Cl)	3,95
Carbonate of soda, (by loss)	14.82
	100.00

No. 4. From deposit by evaporation of Alkaline Pond, near Big Sandy River.

No. 4, (*a.*) From upper part of bank, where deposition commenced:

	Per cent.
Sulphate of soda, ($Na\,O$, $S\,O_3$)	64.65
Chloride of sodium (Na, Cl	35.46
	100.11

No. 4, (*b.*) Taking half way between upper and lower limit of deposit:

	Per cent.
Sulphate of soda, $Na\,O$, $S\,O_3$)	94.92
Chloride of sodium, (Na, Cl)	5.23
	100.15

No. 4, (*c.*) From lowest part of pond, when last deposition took place, consists of slender orthorhombic prisms of pure sulphate of soda—shenardite:

	Per cent.
Sulphate of soda, ($Na\,O$, $S\,O_3$)	100.00

All the specimens appear to be absolutely free from any salts of potassa, an examination by the spectroscope even failing to show the presence of that base.

PART III.

REPORT OF PROFESSOR CYRUS THOMAS.

PART I.—AGRICULTURE.

PART II.—A LIST AND DESCRIPTIONS OF NEW SPECIES OF ORTHOPTERA, WITH REMARKS ON THE *CALOPTENUS SPRETUS*, OR "HATEFUL GRASSHOPPER."

REPORT.

DEAR SIR: I herewith present a report of my investigations in regard to the agricultural capacity of that part of the Rocky Mountain region over which your operations as United States geologist have extended during the past season. Although the immediate route of this expedition was confined principally to Wyoming Territory, I have, in accordance with your instructions, endeavored to complete my report on that part of Colorado and New Mexico examined in 1869. By your direction I also visited the Salt Lake basin, and have added a short account of that interesting section, including a few items concerning other portions of Utah.

At the risk of being somewhat monotonous by the repetition of similar details, I have endeavored to confine myself strictly within the limits of the subject upon which I have been required to report.

Instead of giving details in a journalistic form, which would have amounted to little more than an itinerary, I have endeavored to follow out as far as possible the plan pursued in my report of last year, describing the areas in these Territories drained by the large rivers, as separate districts. I have divided the entire region into two parts called "divisions," one including the area east of the divide, between the waters of the Atlantic and Pacific, and the other the area west of it. The eastern division contains five districts, corresponding with the Rio Grande, Arkansas, South Platte, North Platte, and Wind Rivers. The western comprises the Green River District and Great Salt Lake basin.

I have attempted in most instances to make some estimate of the amount of tillable lands in the different districts and sections.

As a matter of course I do not claim that these are anything more than approximations, made in some instances upon slender data, yet they are not mere guesses, but are made up from estimates of the smaller subdivisions and separate areas, and are, at least, near enough the correct amounts to give a general idea of the agricultural value of the different districts and sections. Although I exclude from these estimates any probable future success and use of artesian wells, yet I include all possible present means of irrigation.

Respecting those parts of these sections which I was unable to visit in person, I have endeavored to obtain the most reliable information possible.

Your operations during the past season have developed the fact that in regions which have generally been considered sterile and unproductive, there are large areas of land which by proper efforts may be rendered tillable and made to produce useful crops.

In my investigations I have constantly looked forward to the construction of a map of these Territories which will show the comparative extent and locality of the irrigable areas, the pastoral lands, and the timbered sections. Such a map, accompanied by a condensed statement of all important facts connected therewith, would not only be of great value to those who contemplate removing to the West, but would be a valuable *vade mecum* for our public officers, Senators and Representatives, and the public generally.

The subject of irrigation is one inseparably connected with the agricultural development of this section, and deserves to be carefully studied. The time given for the preparation of this preliminary report has been too short to enter upon a thorough discussion of it, but I have added a few facts in my concluding remarks, in order to direct attention to the data needed in its investigation.

If you continue your surveys I would suggest the propriety of filling up as rapidly as possible the vacuities in the data obtained in regard to the sections already passed over. I am aware that you did not possess the facilities for doing this in your previous expeditions, but the value of your previous labors, so far as the agricultural investigations go, will be very much enhanced by doing this. I allude to the measurement of the principal streams, their descent, volume, velocity, &c., and the comparative altitude of the different levels and plains above the level of the irrigating streams, by some instrument more accurate than the barometer.

I take pleasure in acknowledging my obligations to the citizens generally along our route, for information obtained from them, and especially to the officers and others at the military posts, for their uniform kindness and willingness to assist me in my investigations. I am also under obligations to the Denver Pacific and the Kansas Pacific Railroads, for passes over these roads and information furnished. Nor can I refrain from mentioning the fact that I am indebted to Wm. N. Byers, esq., of Denver, and Dr. Latham, of Laramie City, for valuable material furnished me for this report.

I am aware this report bears marks of haste, and that it is far from being complete, but trusting that it will prove satisfactory,

I remain yours, very respectfully,

CYRUS THOMAS.

Professor F. V. HAYDEN,
United States Geologist.

PART I.—AGRICULTURE.

INTRODUCTION.

In studying the agricultural capacity of the vast Rocky Mountain region and broad plains of the West, and calculating the probable development of the same, it is necessary to lay aside, to a great extent, all our ideas of agriculture based upon experience in the States. For not only are the physical aspects of this portion of the West so different from the eastern half of our country as to strike the most superficial observer, but the climate is almost completely reversed, the thermometric and hygrometric conditions bearing no such relations to vegetation and agriculture here as there.

Hence, the criteria by which we judge of the fertility and productiveness of the soil, and of its adaptation to given products, (except, perhaps, the strictly chemical test,) do not hold good here. The pale appearance of the soil, the barren look and stunted growth of a spot, are by no means conclusive evidences of its sterility, for the application of water may show it to be rich in vegetative force. Plants which are considered as incompatible in other sections are often here found growing side by side, while others usually associated are here never, or but seldom, found together. Even the constants—latitude and elevation—cannot always be taken as true indices of temperature and vegetable life, on account of strong counteracting local influences. The temperature of a valley, during the latter half of the summer and through autumn, may present an average which would indicate a climate adapted to the production of even tender fruits; while a record of the temperature of the same place, during the spring and the first half of the summer, would show a very different average. And even a knowledge of this fact may not thoroughly acquaint us with the climate and the agricultural capacity of the place, as the presence of lofty mountains near by, with snow-covered summits, may reduce the temperature of the nights very low as compared with that of the day, and thus retard the growth of crops which otherwise would mature and produce well. On the contrary, at other points a lofty range may act as a wall against the cold winds, and under its cover may be found nestling little valleys with a comparatively mild climate. Nor are these imaginary cases, for I could refer to numerous instances of each class.

Hence, I conclude that any attempt to generalize by taking latitude and elevation, or even the average annual temperature, would require so many exceptions that the result would be of no practical value. Yet these are by no means to be excluded.

On account of the reasons given, and others equally potent which might be mentioned, the agricultural capacity of this region must be studied from its own stand-point; and each section must be carefully examined. Otherwise we are very apt, from our experience in other portions of the country, to form erroneous conclusions. Injustice, on this account, is often done to this section by travelers who pass hastily through it, along the railroad lines, judging of the fertility and productiveness of a spot by comparing it with the rain-moistened land of the States. I recollect an incident which will serve to illustrate the truth of this remark. Riding in the cars, along the slightly-elevated bottom which flanked a little stream, but which, to the eye, had a very barren appearance—being sparsely covered with "grease-wood" (*Obione canescens*) and little tufts of dry grass—I remarked to a passenger that, notwithstanding its barren appearance, this bottom could be irrigated from the stream and would produce good crops of wheat, oats, barley, and the hardier vegetables. I could see that this remark provoked a smile of derision on the countenances of those in ear-shot. Yet if they had gone a few miles from the road they could have seen my assertion verified. But this erroneous idea stops not with the uninterested traveler, who is only anxious to reach the terminus of his journey; even official documents, issuing from quarters we would have supposed best informed, have sometimes too hastily and in too general terms condemned this vast area as sterile and desolate.

The following extracts from an opinion deliberately penned, even after the extensive surveys of 1853 and 1854, will stand in strong contrast with the evidences of to-day:

> The concurring testimony of reliable observers had indicated that the second division, or that called the sterile region, (the Plains), was so inferior in vegetation and character of soil, and so deficient in moisture, that it had received, and probably deserved, the name of desert. This opinion is confirmed by the results of recent explorations, which prove that the soil of the greater part of this region is, *from its constituent parts, necessarily sterile;* and that of the remaining part, although well constituted for fertility, is, from the absence of rains at certain seasons, except where capable of irrigation, as uncultivable and unproductive as the other. This general character of extreme sterility likewise belongs to the country embraced in the mountain region.

The writer then proceeds to sum up the areas susceptible of cultivation as follows: Near the route of the 47th parallel one thousand square miles; along the 41st and 38th parallels only the Great Salt Lake basin, estimated at one thousand one hundred and eight square miles; and that in New Mexico at seven hundred square miles.

Experiments made during the fifteen years which have elapsed since the above was written, have shown that about one-third of the entire amount of arable land mentioned can be found in the little triangle between the South Platte and the mountains, in Northern Colorado.

Startling as the statement may appear to those who have swept across the continent along the barren-looking track of the Union Pacific Railroad, I assert it as my firm conviction that there are but few lands in all this portion of the country which are really unproductive; that wherever there is soil, if water can be applied to it, it will be found rich in all the primary elements necessary to the production of useful crops of some kind. Without water as a matter of course it cannot be made to yield, and the crops produced will vary with the climate; but these facts do not affect the position I take in regard to the primitive fertility of the soil.

As I have heretofore stated that the tests of fertility in the rain-moistened regions would not apply here, the question may be asked, Upon what is the assertion based that this soil possesses the elements of productiveness? Upon numerous experiments, the only means I know by which I could have been convinced of the fact.

It is only after a careful examination of a vast number of experiments made in New Mexico, Colorado, Wyoming, Utah, &c., that I am forced to acknowledge what I before did not believe, viz: *that wherever there is soil in these regions, it is rich in the primary elements of fertility.*

Emory, in his "Reconnoisance in New Mexico and California," speaking of the Moro Valley, says: "The plains were strewed with fragments of brick-dust colored lava, scoriæ, and slag; the hills to the left capped with white granular quartz. The plains are almost destitute of vegetation; the hills bear a stunted growth of piñon and red cedar." And although he adds that rain had recently fallen, and that the grass in the bottom was good, yet it fails to obliterate the picture of barrenness he had drawn. But that which wore such a desolate appearance in 1846 is now one of the richest wheat-growing valleys in the whole Territory, its only rival being the Taos Valley, which was once covered with nothing but sage-bushes, (*Artemisia*,) and was likewise counted as barren and worthless.

Nestling high amid the snow-crowned granite peaks of the Rocky Mountains lies the little valley of the Upper Arkansas, where we would scarcely expect to find an arable spot. Yet experiment proves that even this elevated place, covered with the rough local drift from the barren metamorphic peaks around it, when irrigated, is productive, and yields rich crops of the cereals, potatoes, &c. The fossil-bearing deposits in the Bridger basin, on account of their worn, washed, and barren appearance, have been compared with the *Mauvaises Terres* of Dakota, and have generally been considered by travelers utterly worthless in an agricultural point of view; yet the productive farms along Smith's Fork will suffice to convince the most incredulous of the error of this opinion. Necessity for a supply of fresh vegetables to the mining population around South Pass has brought out the fact that the valleys along the tributaries of Wind River will produce fine and abundant crops of all the hardier vegetables. And almost on the mountain crest at Fort Sanders the industrious officers and soldiers of the post have demonstrated the fact that, despite the barren appearance of the soil, the bleak winds of their elevated position, and the early frosts and snows of their climate, useful crops can be produced even here; and prolonged experiments have shown that even spots so thickly frosted over with alkaline deposits as to destroy vegetable and animal life can be rendered fertile and made to produce abundant crops.

As a final illustration, I would refer to the efforts of the Mormons on the Rio Virgin, along the Arizonian border, where I might truly say, amid basaltic hills and drifting sands the desert is being turned into a blooming garden. Perhaps a more desolate-looking region than the vicinity of St. George could scarcely have been selected; yet the application of water shows that here, as elsewhere, the soil is rich in the mineral elements necessary to fertility.

Another fact with which our investigations must begin is, that as a rule, which has but few exceptions, irrigation is necessary to the cultivation of the soil.

As water is, therefore, the great desideratum in the agricultural development of this country, in the method of its distribution we shall find the true key to the agricultural systems of the West, and its turning sheds the boundaries of the districts. I adopted this as the basis of the plan of my report of last season, and subsequent and more extended observations and investigations have served to confirm me in the position then taken.

If I am correct in the foregoing opinions, then a general description of the arable lands of this section implies a description of the portions that can be irrigated. But a description of what may hereafter possibly become arable widens the field and introduces the question of an increase of moisture, with which I do not propose dealing at present, but may allude to hereafter.

Although there is not one monotonous uniformity throughout this vast extent of country, yet there is nothing like the variety to be found between the Mississippi and Atlantic. To know that a given spot is covered with a sufficient depth of soil, and is susceptible of irrigation, is to know that it will produce the cereals, the common vegetables and fruits, except so far as limited by climate. The change in soil and vegetation in passing from the eastern to the western slope of the great divide between the waters of the Atlantic and Pacific is far less than is generally supposed.

During the two years I have been connected with the United States geological survey of these Territories, having traversed the country north and south, from the banks of the Rio Grande to the southern tributaries of the Yellowstone; and east and west from the plains east of the Rocky Mountains to the Great Salt Lake basin, I shall give, in as full and comprehensive manner as possible, in a short preliminary report, a description of the various arable districts embraced within the boundary mentioned, omitting what has already been reported upon. Following out the plan already suggested, the different water-sheds, and systems of valleys which lead to the large streams that drain the country, will form the districts to be considered separately. And these are generally so well marked that but little difficulty is experienced in tracing them.

The central axis of the Rocky Mountain chain divides this area into two unequal and irregular divisions; the eastern division being drained by the following rivers: the Rio Grande, the Arkansas, the Platte, and the Big Horn, which form the water systems of the eastern shed within the territory under consideration. The western division comprises two very different systems, the one being drained by Green River, whose waters ultimately reach the Pacific through the Gulf of California. The other is the Great Salt Lake basin, whose waters empty into the lakes contained within it, or are lost in the sands of its plains.

THE EASTERN DIVISION.

As before stated, this division includes all the territory under consideration which lies east of the divide between the waters of the Atlantic and Pacific. It embraces the areas drained by the Rio Grande, the Arkansas, the Platte, (or rather the Plattes.) and the Big Horn Rivers and their tributaries. These areas, although very irregular and unequal, are generally separated from each other by very distinct boundaries, and can be traced without difficulty.

The Rio Grande basin, although belonging to this division, because its waters find their way to the Atlantic, is in fact situated in a bifurcation of the Rocky Mountain range, pointing southward. And as the larger and loftier extension of this bifurcation is the eastern prong, the basin lies west of it. The western rim of this division, which is the divide between the waters of the east and the west, beginning at the southern extremity and going northward, runs about as follows: With the Mimbres Mountains to the plains of San Augusta; thence slightly northwest along the Zuni range to Campbell's Pass, where, turning northeast, it passes along Mesa Fachada to the Sierra de San Juan, which forms the western rim of the San Luis Valley. From the vicinity of Coochetopa Pass, running west of the Upper Arkansas Valley, and west of South Park, it suddenly turns eastward and winds around Middle Park, throwing this basin on the west. North of this it again bends westward around the North Park, where the character of the range is again changed. Losing its compact form, it breaks up into irregular branches and broken chains, separated by elevated intervening plains, which are traversed by short ridges and mountains. The main divide, which is less elevated here than farther south, bends somewhat abruptly to the northwest, connecting with the Wind River Mountains, near South Pass. The latter range forms the western boundary of the Big Horn basin, the northern district of the division under consideration.

The eastern boundary of this division, as fixed by nature, is the line where irrigation becomes necessary as we move west from the Mississippi. But since this is difficult to determine definitely, I have limited my examinations to the boundaries of the three Territories within which the work of the expedition was principally confined during 1869 and 1870. This embraces nearly all of New Mexico, the eastern half of Colorado, and (by including the Powder River country) all of Wyoming, except a small triangular area in the southwest corner, and amounts in the aggregate to about two hundred and fifty thousand square miles.

Of this area perhaps three-tenths, or seventy-five thousand square miles, could not be cultivated if every other obstacle except its ruggedness were removed. Of the remaining seven-tenths we may set down five-tenths as at present without a sufficient supply of water for irrigation. This leaves two-tenths, or about fifty thousand square miles, which are, or may be rendered arable by irrigation, and which, at a moderate estimate, would support a population of several millions. It is true that this is but an estimate in round numbers, liable to be considerably modified, and which will, by many, be considered as exaggerated, but I make it after having traversed the entire division from one extremity to the other; and I believe it will prove to be nearer correct than the limited estimates which have heretofore been made in regard to the cultivable lands of these Territories. And I think it quite probable that additional and new methods of obtaining, husbanding, and applying water, as by reservoirs, wells, pumps, elevating machinery, &c., may show that even this estimate is far below the proper figures.

Efforts already made, and canals under way and projected in this division, when completed, will demonstrate the feasibility of bringing under culture a large extent of the lands in these Territories lying east of the mountains.

In order to avoid repetition and confusion I shall follow out the plan adopted in my last report, using the term "district" to designate the area drained by one of the large streams named, (the Plattes, north and south, being described separately;) the term "section" being applied to the larger subdivisions of a district. The terms "tillable," "arable," "susceptible of cultivation," not being used as excluding the idea of the future possibility of cultivating other portions, but simply to express the fact that those portions so termed are now sufficiently supplied with water for farming purposes.

THE RIO GRANDE DISTRICT.

This district, although chiefly confined within the bounds of New Mexico, penetrates into the southern portion of Colorado. Beginning at Poncho Pass, about 38° 30′ north latitude, it extends southward to the southern boundary of the Territory, and is about five hundred miles long. As far south as Santa Fé its width is tolerably uniform, averaging very near one hundred miles; but here it begins to expand rapidly on the eastern side to embrace the area drained by the Pecos, terminating in this direction in the *Llano Estacado*. Excluding the "Staked Plains" from our calculation, the entire area of this district amounts to about seventy thousand square miles, about five thousand five hundred of which belong to Colorado, (according to the old boundary line.)

This district may conveniently be divided into three sections, corresponding with the natural aspect of the country: First, the San Luis Valley, (sometimes called the San Luis Park,) which constitutes that portion of the district which lies north of the point where the Rio de Taos enters into the Rio Grande; second, the central portion of the Territory, including the Rio Grande Valley proper and the tributary valleys leading into it between the southern rim of the San Luis Valley and the southern boundary of the Territory; third, the Pecos Valley, which, beginning east of the mountains, about opposite Santa Fé, runs a little east of south to the Texas line, and includes only the area drained by the Pecos River.

This district embraces nearly two-thirds of New Mexico, leaving a strip along the western boundary varying from fifty to one hundred miles in width, and drained by the tributaries of the Colorado and Gila Rivers, and a triangular area in the northeast corner drained by the Canadian River. It embraces the central, and, with the exception of a few valleys, the most productive portion of the Territory; and, although much of it is occupied by broken ranges of mountains and elevated mesas, yet there is a large portion which can be irrigated by the streams that traverse it, and a still larger ratio which affords rich pasturage for sheep and cattle. Here also can be found every variety of climate, from the cold of the mountain region along its northern rim, to the tropical valleys of its southern border.

SAN LUIS VALLEY.

This valley, or park, has been correctly described as "an immense elliptical basin enveloping the sources of the Rio Grande." Its entire length, in a direct line from the summit of Poncho Pass to the mouth of the Rio de Taos, is about one hundred and fifty miles, and its greatest width, counting from the crest of the rim, about one hundred miles; but its surface area cannot properly be estimated at more than one hundred and forty miles long, by an average width of sixty miles, giving an area of eight thousand four hundred square miles. Of this amount perhaps one-fourth, or about one million three hundred and fifty thousand acres, can be irrigated and brought under cultivation by ordinary means, and by damming up and drawing off in canals the waters of the Rio Grande the area of cultivable land may be expanded above these figures.

The mesa plains, mountain foot-hills, and slopes afford nutritious grasses suitable to the pasturage of sheep and cattle. The average elevation of the surface is about seven thousand feet above the level of the sea.

The northern part of this section is occupied by an isolated basin of considerable extent, to which the name San Luis Park is sometimes limited; it is also called the "Rincon," and "Sahwatch Basin." The waters of this basin, instead of entering the Rio Grande, are poured into a reservoir near the western base of the Sierra Blanca, which has received the name Sahwatch Lake. For a long time the very existence of this lake was a matter of doubt, and even at the present day, with settlements beginning around it, its extent is a matter of dispute, the estimates varying from three to sixty miles. I cannot describe this singular basin and reservoir in any better manner than by quoting the language of the United States geologist, (chief of our expedition,) found in his preliminary report of last year: "This northern portion [of the San Luis Valley] above the bow of the Rio Grande is about sixty miles in length, and has an average width of fifteen or twenty miles. About the center (rather in the southeast part) of this park is a singular depression, about ten miles wide and thirty miles long, which looks like one vast thicket of grease-wood (*Sarcobatus vernicularis*) and other chenopodiaceous shrubs. Into it flow some twelve or fifteen good-sized streams, and yet there is no outlet, neither is there any large body of water visible. It seems to be one vast swamp or bog with a few small lakes, one of which is said to be three miles in length. Although disconnected from any other water system, the little streams are full of trout."

The boggy nature of the broad margin, the shallowness of the streams where they enter it, and want of interest on the part of those residing in the vicinity, have probably prevented an examination sufficient to determine, with any degree of accuracy, the extent of the lake or lakes contained therein. During the spring and early part of summer the streams which run into it must carry down a large amount of water, part of which probably sinks into the margin which has dried during the autumn, the rest evaporating into the dry atmosphere. The streams on the east side generally dry up in the latter part of the season, but those on the west and north are constant runners.

Commencing at Poncho Pass on the northern extremity of the section and moving southward, we enter the valley of Homan's (or San Luis) Creek, which expands for a part of its length into what is called Homan's Park. This is about four or five miles wide at its broadest part, and some seven or eight miles long. The arable portion, which lies chiefly on the west side, although somewhat inclined, can be easily irrigated from the little streams which descend across it to the principal channel The soil, though mixed with coarse sand, is quite good, and will produce good crops of wheat, oats, and the hardy vegetables, the climate being too cold for anything of a tender nature. Some trees of a considerable size, principally cottonwood, grow in the valley, while the mountains around produce an abundance of pine.

The soil of the lower level, especially near the north end, is strongly impregnated with alkali.

This is a most excellent point for a few stock ranches, as water is abundant, and as not only the valley proper, but also the little openings up into the mountains and slopes on the north and west, afford most excellent grass, and would furnish pasturage for quite a number of cattle.

Below this point the valley contracts, but again expands near where it opens into the Sahwatch Basin, affording a small area of arable land. Here also are a number of hot springs which emit a strong vapor, the temperature ranging at about 120° Fahrenheit.

Running in from the northwest is Sahwatch Creek, which affords a rich valley some three or four miles wide and some ten or twelve miles long. The bottoms which flank this stream are generally flat, and as they are raised but slightly above the water-level, can be easily irrigated, the supply of water being abundant. A settlement has already been made here, and although the seasons are short, yet experiment has proved that wheat, oats, &c., can be profitably raised, the yield being good and the grain fine. I dislike to introduce personal incidents into a report of this kind, yet as they sometimes serve to give stronger impressions than can otherwise be made, I trust I will be excused for introducing one here to show how difficult it is to produce a belief in the agricultural capacity of these regions. As we entered this valley from the west, we noticed that the oats, which appeared to be of a very inferior quality, had been cut quite green; this was late in the season, (September 30,) and the night was very cold and frosty. I at once concluded that the climate was too cold and the seasons too short to produce the cereals, and even the leader of our expedition, who had been exploring the Rocky Mountain regions for fifteen years, and who long since had gotten over first impressions, was inclined to the same opinion. Yet next morning, when we passed over to the other side of the valley, we were surprised to see some large fields of the finest quality of wheat. Although it was being harvested at this late date, having been sowed late in May, the grains were large and plump, and fully ripened.

The broad margin that surrounds the boggy basin before described, is sufficiently level for agricultural purposes, and, as far as the supply of water will go, can be easily irrigated and brought under cultivation. The lands along the east side, which slope in from the base of the Sierra Blanca, are rather sandy, and in places almost destitute of vegetation, the supply of water on this side not being constant. Yet I think it probable that during the spring and first of summer, when most needed, and while the snows on the west side of the mountain are melting, there will be a sufficiency of water to irrigate a considerable breadth of land even here.

On the west side are the Carnero and Gareta Creeks, pretty little streams which pour down their pure, limpid waters through ditch-like channels but a few feet below the surface of the plain, rendering the irrigation of the bordering lands remarkably easy and inexpensive. The soil here is very good, in some places being a dark, rich loam, covered with a tall and rank growth of grass. The temperature is about the same as in the Sahwatch Valley, but although more open and perhaps warmer during the day, is more subject to irregular early frosts, a fact which is often noticed in comparing the climate of open plains with that of adjacent mountain valleys.

Should the time come when there will be an urgent demand for land in this vicinity, an encroachment could be made upon the marshy borders of the central basin, which if redeemed would afford several thousands of acres of rich soil.

On the southwest this basin is bordered by a somewhat elevated, gravelly plateau, varying in width from eight to fifteen miles, which, beginning at the mountains on the west, passes eastward between the Rio Grande and Gareta round the south end of the basin, separating it from the Rio Grande bottoms. In regard to the possibility of irrigating this ridge I will speak hereafter.

The Rio Grande, rising in the mountains to the west, flows directly east until it reaches the middle of the valley, where, making an abrupt bend, it runs south through the entire length of the valley, dividing it into nearly equal parts. On the east side, between the Sahwatch basin and the Rio Costillo, lies a broad, slightly-inclined plain, averaging about twenty miles in width. It is interrupted, in its southwest portion, by a mesa of considerable extent, and by occasional foot-hills which shoot out from the mountain on the east. The southern half is undulating, but the northern portion is composed of three levels: first and lowest, the river bottom, some five or six miles wide; the second corresponding with the plateau before mentioned, and which occupies the region about Fort Garland, having an area of one hundred and fifty or two hundred square miles; the third, which is the highest, lying south of the second. The bottoms along the Rio Grande are composed of deep rich soil, generally covered with tall grass, or thickets of bushes, with here and there open groves of cottonwood. They can, without much difficulty, be irrigated from the river, but I am of the opinion (and on this account have been thus minute in my description of this locality) that, by commencing a canal where the river emerges from the mountains, and bringing it along the plateau and around the bend upon the second level, not only the plateau and a great portion of the second level, but the southern slope of Sahwatch basin and Rio Grande bottoms might all be irrigated from it. It is possible there may be a depression between the Rio Grande and Gareta at the upper portion, which would necessitate the building of an aqueduct, and thus increase the expense, but in regard to this I cannot speak positively. This canal would irrigate at least five hundred thousand acres, at a moderate cost per acre.

From the Trenchera most of the eastern portion of the second level can be irrigated; and it is possible a portion of the higher level might be reached by water from this stream and the Culebra, near their sources in the mountains.

An old Mexican claim extends over a considerable portion of this part of the valley. Reaching from the south end of the Sierra Blanca to the Rio Costillo, it embraces the entire valleys of the Trenchera, Culebra, and Costillo, amounting to one million three hundred thousand acres.

The Rio Culebra furnishes one of the prettiest and richest valleys of this section, its chief expanse being along the eastern margin near the mountains, from which numerous little tributaries pour down their cool, clear waters. This expanse, lying between the mountains on the east and the "cerillos" on the west, has been very appropriately designated the "vegas" or meadows, on account of the luxuriant growth of grass that covers its soil. There is quite a settlement here, chiefly Mexican, and a large portion of the valley at this point is already under cultivation. The county seat of Costillo County, San Luis, (or Culebra,) is located here. The second or upper level here, and also that bordering the Costillo Valley, might be irrigated, thus increasing the breadth of the arable area. Near the Rio Grande lie a succession of basaltic mesas and ridges, through which the Culebra and Costillo have cut channels for their waters. The Rio Grande affords no bottom along this part of its course, its waters being confined to a deep narrow cañon of basalt for sixty-five miles, from La Joya to the crossing of the road to Conejos. The Rio Colorado affords another valley of moderate width, which, like the others, is broadest and most extensive at its upper end, narrowing as it approaches the Rio Grande. Between this and the Taos Valley, though a few spots of limited extent may be found which can be cultivated, the greater part is elevated and broken, and is covered with a heavy growth of timber.

The area west of the Rio Grande is similar in character to that east. It is watered by Pintado Creek, Rio de Jara, and the Conejos River, and contains some as fine land as is to be found in the San Luis Valley.

The valleys of the Pintado and de Jara are of but moderate extent, traversing a more uneven country than that farther south. The Conejos River and its tributaries afford a valley which at its central part presents a broad and fertile area, where quite a number of Mexican settlements have already been made. The southern portion of this side of the San Luis Valley is principally an elevated basaltic plateau, or mesa, which is covered with grass, and well adapted for grazing purposes, but cannot be brought under cultivation, as it is beyond the reach of irrigation. But there is on this side, as on the east, a large extent of land, principally on the second level, which by proper efforts might be irrigated, thus adding a broad margin to the arable lands of this section.

The soil of the lower valleys and bottoms throughout the section is generally composed of a rich sandy loam, containing more or less comminuted marl. That of the upper levels and ridges has more or less gravel and coarse sand mingled with it.

Having an elevation of seven thousand feet above the level of the sea, and being partially surrounded by mountains, whose summits bear upon them snow throughout the year, this basin must necessarily have a tolerably cold climate. Yet the days and the average temperature during the growing season, as shown by the thermometer, would indicate a more favorable climate than the surroundings do; but this is to a certain degree deceptive, as the nights during the warmer half of the year are quite cold as compared with the temperature of the days. And this fact, as will be seen, has an important bearing in estimating the agricultural capacity of this section. Frosts generally set in between the 1st and 10th of September, but snow seldom begins to fall on the plain until December, and the amount that falls during the winter is small.

There is scarcely any portion of the valley that does not afford good pasturage for cattle and sheep, and when every acre that can be irrigated has been brought under cultivation, the higher ridges, mountain sides, and elevated valleys will still furnish sufficient pasturage for numerous herds and flocks; and if a means of reaching market is ever obtained, few better places for the manufacture of butter and cheese than this can be found.

From Mr. Stephen E. Sterrett, who has been acquainted with this valley for eighteen years, and has resided here for the last ten years, I obtained the following information in regard to the crops.

The principal products of the soil are wheat, oats, and potatoes, very little corn being raised. Wheat is generally sown between the 1st of April and 10th of May, and harvested from 1st to the 20th of September, the average yield being thirty bushels, which he considers a low estimate, as he has seen fields turn out as much as sixty bushels to the acre. He says the reason why their harvest is so late is because the cold nights in the spring check its growth, and in the latter part of the summer retard its ripening. Oats grow finely, and yield about forty bushels to the acre. Some corn is raised, principally in the southern end of the valley, yet the seasons are so short, and its growth so much retarded by the cold nights, that it is often injured by autumnal frosts, and even when it matures is of an inferior quality, and the yield light. He finds by experience that in the northern part of the valley it is less liable to injury if planted near the mountain than on the open plain.

Irish potatoes do well, yielding moderate returns of fine-flavored tubers. Turnips and Mexican squashes can be easily raised. Such garden vegetables as cabbages, beets, carrots, peas, &c., can be grown here without difficulty; and tomatoes and beans can be raised, but are liable to be injured by the frosts. Very little fruit has hitherto been raised in the valley, but I think if the proper varieties of apples were selected and well managed, a sufficient quantity might be produced to supply the local demand. Currants, raspberries, gooseberries, and strawberries will grow here and produce fruit, but the cultivated varieties will have to be planted, for although the mountain sides furnish an abundance of the wild kinds, they appear to fail when transplanted to the Plains.

Ample water power for milling and manufacturing purposes can be readily obtained; and a supply of timber can be had by going to the mountains, especially at the northern and southern extremities of the valley, and it is very probable a large amount of the better kind for building purposes might be floated down the Rio Grande, as far as this river has accessible points.

The roads within the valley are mostly good; and those which lead out of it at Poncho and Sangre de Christo passes and at the south end can be made good without any great expense.

I have been thus minute in my description of this basin because much interest has been manifested concerning it of late years, and yet so little in regard to its agricultural capacity seems to be known.

The reader will notice that I have omitted to speak of the Taos Valley in my description of this basin, although in giving the boundaries I included it. I did so because it is wholly distinct in its character from the rest of the basin, and is almost completely isolated.

TAOS VALLEY.

"The valley in which Taos is situated may be said to be formed by a notch or bend in the mountain range. On the southwest is the Picaris Range, with a strike nearly northeast and southwest. The next range east of this trends about north and south." It is about eighteen miles in extent from east to west and sixteen from north to south, the narrow valley of the Arroyo Hondo forming its northern extremity. There is also an open area, about eight miles wide, on the west side of the Rio Grande, which may properly be counted as a part of it. The entire area, including the strip west of the river, amounts to about two hundred and fifty square miles, or one hundred and sixty thousand acres, a large part of which may ultimately be brought under cultivation.

The deep arroyo or valley at the north end is from one to two miles wide, affording a fertile spot, easily irrigated, where there is a small Mexican settlement and village.

The entire valley of the Taos seems to have been one broad field of sage, (*Artemisca*,) which, on the parts where it has not been disturbed, excludes every other growth, giving a very barren appearance to the landscape.

Besides Taos there are several other villages and settlements, chiefly Mexican, in the southeast part of the valley. The amount of land in cultivation is not more than fifteen thousand acres. Unless the cañon through which the Rio Grande emerges into this valley should present some insurmountable difficulty, the greater part of its area may be irrigated, the northern and western portion from this river, and that part along the mountains from the streams that flow into it.

The soil is quite different from that of the valleys further north, being very finely pulverized and loose; it also is of considerable depth and very fertile. The cause of its fertility will be understood from the following quotation, made from the preliminary report of the United States Geologist on the "Geological Survey of Colorado and New Mexico," 1869, p. 70:

> The valley proper is scooped out of the Santa Fé marls, which must at one time have prevailed extensively, as in the country north of Santa Fé, but the surface has been smoothed off, so that nowhere are the marls conspicuous; still they can be seen all along the base of the mountains bordering the valley, where portions of the recent deposits lie high on the mountain side. No sedimentary rocks of older date are seen, and the Santa Fé marls rest directly on the metamorphic rocks.

The effect of this marl upon the appearance and character of the soil is plainly seen. The consequence is, that that which in its wild state appears as but a barren sage plain, across which the wind sweeps the fine particles of the light soil, piling it in little heaps around the bushes, by the application of water is changed into a fertile field. And I think Colonel Charles McClure justified in his statement to me, that sufficient wheat to supply the Territory might be raised in this valley. It is considered the best wheat-growing region in New Mexico. The climate appears to be milder here than in the San Luis Valley proper, although but narrowly separated from each other, and the differences of latitude and altitude being slight.

Having now completed my description of this great mountain basin, it is proper I should refer to the report of Lieutenant E. G. Beckwith, as published in Vol. II, Pacific Railroad Reports, whose opinion and description differ somewhat from that I have given. He remarks that "in our ride of over a hundred miles from El Sangre de Christo to this place (Taos) we saw no grass in the valleys worth naming, the vegetation being confined almost exclusively to artemisia and a few varieties of cacti, but chiefly the prickly pear; the pines of the mountains at times extend well down to the plains. In the high small valleys of the mountains the grass is luxuriant and the flowers beautiful."

There are parts of the open valley which are not well grassed and that have upon them a tolerably thick growth of artemisia, and also some spots grown up with chenopodiaceous shrubs; but as a whole it may properly be called well grassed. In 1869 our party traveled over exactly the same road here spoken of, camping one night in each of the principal valleys, the Rio Colorado, Rio Costillo, and Culebra, having no difficulty in either in obtaining sufficient grass for our stock. It is true that it was not so rank and abundant in the first two as in the last, which, outside of the cultivated fields, was one rich meadow. The bottoms of the Rio Grande and western slope of the Sahwatch basin we found covered with a very heavy growth of grass.

In summing up his view of this valley, although he calls it one of the finest in New Mexico, yet he goes on to say:

> The extensive valley of San Luis, lying between the Sierra Blanca on the east and Sierra San Juan on the west, and watered by the Rio Grande del Norte and its numer-

ous small tributaries, is, in general, one vast sage plain from the Rio Colorado to Gunnison's Pass. The grass on the lower tributaries of the Rio del Norte, in this valley, is very limited indeed. It is more abundant on the upper affluents, where a few fields of prairie grass a mile or two in width were observed, and the authority of our guide given for extensive grass prairies on the Rio del Norte itself. But all these grass fields, with the greatest amount of cultivation which can be supplied with water from the little streams of this valley, can, under the most favorable circumstances, only support a meager population.

It is evident from these remarks of Lieutenant Beckwith that he bases his conclusions on his observations and experience in the States where the soil is moistened by rain, and that he considers the sage ground as unfit for cultivation. But the experiments of the seventeen years which have elapsed since he was there, have taught us that sage land, when irrigated, is about as productive as the grass fields. And the broad sage field that lies west of Fort Garland, (then Fort Massachusetts,) if redeemed by water, would soon give evidence of this fact.

I do not refer to the reports of others in any spirit of criticism, but as far as possible to correct the impression made by these opinions, which, though given in all candor, frequently did injustice to this country.

VALLEY OF THE RIO GRANDE.

As I have traveled over but a small portion of this section I cannot enter as minutely into details as I have in regard to the one north of it. My description, therefore, will not only be more general, but made up in part from such reliable information as I could obtain. But this deficiency is, to a great degree, compensated by the narrative of Dr. A. Wislizenus, the reconnoissance of Lieutenant Emory, and the reports of General Pope, Lieutenant Whipple, and others, in which notices of the agriculture and arable lands of different parts of the section are to be found.

The length from north to south, counting from the mouth of the Rio de Taos to the Mexican line, is about three hundred and fifty miles, with an average width of one hundred and ten miles. It is difficult to estimate, even with approximate accuracy, the amount of arable land in this area, as, with the exception of the comparatively narrow valley proper of the Rio Grande, it lies in small irregular valleys and detached spots. And, in addition to this difficulty, great diversity of opinion exists in regard to the average width of this valley, varying from two to twenty miles. Yet this difference is not wholly due to error in either party, as the term "valley" is used in different senses, some meaning thereby only the bottoms immediately along the river, while others include the lower terraces which at some points flank the bottoms. Perhaps the best data we have upon which to base an estimate is to be found in the report of Lieutenant Whipple, who, after a careful examination, estimates the cultivable area of a belt thirty miles wide, and one hundred and eighty miles long, east and west—reaching from Anton Chico to Campbell's Pass—at three hundred and sixty square miles, or one-fifteenth of the whole area. As this belt reaches directly across the entire width of the section under consideration, it may be taken as an average of the whole; for, although it includes the valley of the San José on the west, the east end stretches over the broad Mesa de la Vista almost from Anton Chico to San Antonio. This proportion would give for the section nearly two thousand six hundred square miles of tillable land, which I think may be increased by the proper husbanding of water.

In order to understand properly the differences in climate and productions observable in the different parts of this section, it is necessary, not only to take into consideration the latitude, but also the variations in altitude, and proximity to high mountains. Beginning at the San Luis Valley, with an elevation of 7,000 feet above the level of the sea, we find when we reach Santa Fé the height is still 6,840 feet, which is higher than some of the valleys farther north. Keeping on the same plateau, and moving south, the elevations of the principal points are as follows: Gallisteo Village, 6,165; Los Cerillos, 5,804; Cañon Blanco, 6,320, and a little southwest of the cañon, near Laguna Blanca, 6,943 feet. Moving southwest from this point toward Albuquerque, we find the elevation at San Antonio is 6,408 feet. But when we descend into the immediate valley of the Rio Grande, as far north as Peña Blanca, it is only 5,288 feet above the sea-level, or 1,552 lower than at Santa Fé. At San Felipe it is 5,220; at Albuquerque, 5,026; at Isleta, 4,910; at Socorro, 4,560; at Alamosa, 4,200; and at El Paso about 3,800. Strange as it may appear, when we cross the ridge east of Santa Fé, to the headwaters of the Pecos, we find the altitude at Pecos Village but 6,360 feet—about 500 feet lower than at Santa Fé; while at Anton Chico it is only 5,372 feet, corresponding very nearly with that of the Rio Grande valley at Peña Blanca.

I have given these particulars in regard to the elevation of this region to show that, sweeping around the southern terminus of the Rocky Mountain range, is an elevated plateau, or extended mesa, which, reaching north along the inside of the basin for some distance, occupies both sides of the river, but southward recedes from it. At Peña Blanca we descend into the Rio Grande Valley proper, which continues along the southern course of the river with little interruption throughout the rest of the Territory. From this point south, fruits and the tenderer vegetables and plants are grown with ease, which fail no farther north than Santa Fé.

But the difference in altitude is not the only influence tending to vary the temperature and vegetation between the northern and southern parts of the section, for about opposite the point where this lower level begins, the mountain range on the east terminates, and, as a matter of course, the depression of temperature and the cold of the nights, so far as caused by the proximity of snowy peaks and icy waters, also cease.

From the region of the Galisteo south the features of the country change; instead of the vast and lofty ranges of the Rocky Mountains, a succession of shorter, narrower, and less lofty mountains forming a chain which runs directly north and south a short distance east of the river and almost parallel with it; and what is somewhat remarkable, instead of corresponding with the range east of the San Luis Valley, this chain runs almost directly in a line with the bottom of the valley. While the mountains have thus diminished, on the other hand the miniature table lands of the regions farther north are here replaced by vast plateaus which spread over the country forming its general level, out of which are scooped the valleys and basins.

On the east side of the Rio Grande, between the Taos Valley and Joya, the country is broken and mountainous, mostly covered with a heavy growth of timber, chiefly pine and fir. This area is traversed east and west by a few small streams, which are bordered by narrow strips of cultivable lands. The three principal ones are the Peñasco, Pueblo, and Chumesal; the first being a vigorous creek which traverses a valley varying in width from one to five miles, which is flanked on each side by high bluffs. A good part of it is already under cultivation, and, as the soil is fertile and the valley sheltered, the crops produced are quite heavy. The other two are small and less important than the Peñasco.

Between this broken region and the Rio de Canado (or Santa Cruz) on the south, lying along the Rio Grande, is a moderate breadth of arable land, some of which is very fertile, and produces not only the hardier cereals, as wheat, oats, and barley, but also corn, which grows large and fine. The tillable area here could be considerably enlarged by irrigation from the Rio Grande, unless there is some impediment which I failed to observe.

The Rio de Santa Fé, Rio Galisteo, and Tuerto Creek afford strips of arable land, varying in width from one to ten miles; but here also I think the amount might be increased by proper efforts and more extensive acequias.

I have not visited the valleys of the Rio de Chama and Rio Puerco. The valley of the Rio Puerco, I understand, is flanked by elevated table lands, and that its lower portion is not supplied with living water but a part of the year; but its principal tributary, the San José, runs through a fine wide valley, in which there is a considerable amount of cultivated land and a number of villages, the breadth available for agricultural purposes being equal to the capacity of the stream.

The average width of the immediate valley of the Rio Grande, as before stated, has received widely different estimates; Dr. Wislizenus placing it as high as twenty miles, evidently including the lower terrace which is sometimes present, while Colonel McClure stated to me that he would not estimate it at more than two miles, including only the immediate bottoms of the river. Lieutenant Whipple's calculation would give about eight or nine miles as the average, which is probably nearer correct than either of the others.

The following memoranda in regard to various points along this valley, though not very definite, may be of some interest to the reader.

At San Domingo it is quite narrow and continues so for about six miles below San Felipe, where it again widens to six or seven miles, the soil being quite sandy. At Bernalillo it is of considerable breadth, but grows narrow in the vicinity of Zandia, again expanding and affording a tolerably broad area at Alameda. From Alameda to a point some distance below Isleta, there is a moderate width of good bottom land. Contracting near Peralto, it widens again in the neighborhood of Tomé with improved soil, the belt continuing with very little interruption to the bend of the Rio Grande, below the mouth of the Puerco, where the bordering hills close in upon it, reducing it to about one mile. At Socorro there is a medium belt, which expands southward, presenting a very fine agricultural section, which is interrupted in the vicinity of Fra Cristobal Mountains. Between San Antonio and Doña Aña are some of the finest portions of the whole valley, opposite which on the east side stretch the sandy wastes of the dreaded Jornada del Muerto. Near Mesilla and Doña Aña are also some fine openings, which are partially cultivated. In regard to the few small tributary valleys below the Rio Puerco, I know nothing.

The volume of water sent down by this river is sufficient to irrigate an immense area of land. At Tomé Lieutenant Emory found by measurement the entire volume, including two acequias, to be equal to a width of ninety-three feet and depth of two feet, or the area of a transverse section, one hundred and eighty-six square feet. The rate of fall between Peña Blanca and Isleta is nearly six feet to the mile; it may therefore be possible to carry it to some portions of the higher ground, but in regard to this I am unable to speak positively. Judging from the height of the bluff at San Felipe above the river level, one hundred and ninety-six feet, it is not probable this is practicable except where there are lower intermediate levels.

As a general thing the soil along the river is quite sandy, but when well watered proves to be very fertile; and, although seemingly adapted to the growth of wheat, this cereal does not prove as productive here as farther north. Indian corn grows finely, and when the better varieties are introduced and cultivated, large and remunerative crops may be raised. Here is to be found one of the finest grape-growing sections in the Union, its only rivals being the valleys of California. All the usual varieties of fruit can be raised in abundance and with great ease. Melons, pumpkins, frijoles, and in the southern extremity cotton, can be produced. In the greater part of this valley two crops of cereals can be raised in one season.

THE PECOS VALLEY.

As I have visited only the northern part of this section, and have received information in regard to some detached portions only of its southern half, I can form no reliable estimate of the amount of arable land it contains. Yet I am warranted, by what I have seen and learned, in saying that the proportion is less than in either of the sections heretofore described. In fact, the valley of this river is one of erosion, worn out of the broad plateau of this region, and presenting, north of the Guadalupe Mountains, the appearance of one vast *arroyo*. Its tributaries are few, and, with the exception of two or three, of but little importance in an agricultural point of view.

The Gallinas River and its little tributaries afford narrow belts of fertile soil, the area being equal to the supply of water. Around Las Vegas a considerable breadth is under cultivation, corn being the chief crop. The Pecos, to its junction with the Gallinas, runs through a very narrow valley, which has been correctly described as "ribbon-like," a few bay-like expansions forming the only exceptions, as at San Miguel. The valley bottom throughout this distance is generally flanked by high bluffs, which sometimes, as in the neighborhood of La Cuesta, reach an altitude of five hundred feet. Lieutenant Whipple, whose line of survey crossed at Anton Chico, estimates the cultivable land in a belt thirty miles wide and reaching directly across this section, from Pajarito Creek to Anton Chico, at one-thirtieth of the area embraced. From an examination in person of a similar belt immediately north of it, I am inclined to think this estimate very near correct; it may be a little too low, but not much. In the neighborhood of Fort Sumner, as I was informed by Mr. Maxwell, there is a considerable breadth of fertile land which can be irrigated, and which is well adapted to the growth of fruits and grapes. Along the headwaters of the Rio Bonito there are some fertile spots, where not only fine crops of cereals are raised, but where fruits, grapes, and even sweet potatoes grow well. Very little appears to be known in regard to the valley of the Penasco.

From the north end of the Guadalupe Mountains to the mouth of the Delaware River the valley of the Pecos is level and very fertile, averaging in width some three or four miles. But from all I can learn in regard to this part of the section the tillable area could be extended far beyond the immediate bottoms. For here the plateau, instead of terminating in abrupt bluffs, descends gradually, and in a somewhat gentle slope to the river bottom. The supply of water in the river being ample, and the fall rapid in this part of its course, irrigating canals could be carried far up the slope, if not to the top of the plateau. The soil on the upper level possesses all the ingredients necessary to productiveness, except that furnished by water. Supply this and all the table lands of New Mexico will yield rich returns for the labor bestowed upon them.

I am of the opinion that for a part of its course the Pecos is somewhat sluggish, but I may be mistaken in this, as I base it entirely on the following data, viz, that from Anton Chico to the mouth of the Delaware the fall amounts to one thousand two hundred and fifty feet, which gives an average of but little more than four feet to the mile, but as the fall between the north end of the Guadalupe Mountains and the mouth of the Delaware is very rapid, and at the upper portion is also above the average, I infer that for a part of its intermediate distance the fall is but little.

WESTERN NEW MEXICO.

Although this is not embraced in the Rio Grande district, it is perhaps best to add here what few items I have obtained in regard to its agricultural capacity.

The Rio San Juan, a tributary of the Colorado of the West, although rising in the San Juan Mountains of Colorado Territory, bends south and traverses the northwest portion of New Mexico, where it receives a number of affluents. Colonel McClure and Governor Arny inform me that these valleys afford a considerable breadth of very rich land, which can be irrigated, and which will produce fine crops of the cereals, vegetables, and fruits usually grown in the Middle States. As this area appears to be almost, if not entirely, unoccupied, it would present a good point for a colony.

The upper tributaries of the Puerco of the West, a branch of Flax River, are flanked by narrow belts of arable lands, but as the water of this river sinks as it descends, it cannot be relied on for irrigating purposes. But near the mountains here, as along the headwaters of the Zuñi, crops may be raised without irrigation, as the supply of rain is said to be generally sufficient for this purpose. Even around Zuñi, where an ample supply of water can be obtained from the Zuñi River, there are no acequias, the inhabitants relying on the rains to supply the necessary moisture. There is probably some peculiarity connected with the local atmospheric currents here which collects the moisture, or causes its separation and fall. The evidences of a former quite numerous population, which have served to render this classic ground, when we consider the fact that they are unaccompanied by the remains of aqueducts, would indicate that formerly the amount of rain was sufficient for agricultural purposes.

The Rio Mimbres runs through a beautiful valley of moderate width and fertile soil, where all the productions of the Central States can be raised, and where even those things which belong to a more southern climate can be grown without difficulty.

The Rio Gila, near where it leaves the Territory, has some good bottom lands, but farther north, toward the Sierra Santa Rita, is pebbly and inferior. In regard to the valleys along its head-waters I know nothing.

SOIL, CLIMATE, AND PRODUCTIONS.

Leaving the description of the Canadian section until I come to the examination of the Arkansas district, I will close my account of the Rio Grande district with a short summary of the information obtained in reference to the soil, climate, and productions of the Territory.

As a general thing the soil is sandy and looks poor and sterile, giving an impression of extreme barrenness, which it is difficult to remove until the effect of irrigation and cultivation is seen. But the general statement made in the introduction respecting the soil in the Rocky Mountain region holds good here, for wherever sufficient water can be applied the soil will prove fertile.

The best estimate I can make of the arable area of the Territory is about as follows: in the Rio Grande district, one-twentieth, or about two thousand eight hundred square miles; in the strip along the western border, one-fiftieth, or about six hundred square miles; in the northeastern triangle, watered by the Canadian River, one-fifteenth, or about one thousand four hundred square miles. This calculation excludes the "Staked Plains," and amounts in the aggregate to four thousand eight hundred square miles, or nearly two million nine hundred thousand acres. This, I am aware, is larger than any previous estimate that I have seen, but when the country is penetrated by one or two railroads, and a more enterprising agricultural population is introduced, the fact will soon be developed that many portions now considered beyond the reach of irrigation will be reclaimed. I do not found this estimate wholly upon the observations made in the small portions I have visited, but in addition thereto I have carefully examined the various reports made upon special sections, and have obtained all the information I could from intelligent persons who have resided in the Territory for a number of years.

As the Territory includes in its bounds some portions of the Rocky Mountain range on which snow remains for a great part of the year, and also a semi-tropical region along its southern boundry, there is, of necessity, a wide difference in the extremes of temperature. But with the exception of the cold seasons of the higher lands at the north, it is temperate and regular. The summer days in the lower valleys are sometimes quite warm, but as the dry atmosphere rapidly absorbs the perspiration of the body, it prevents the debilitating effect experienced where the air is heavier and more saturated with moisture. The nights are cool and refreshing. The winters, except in the mountainous portions at the north, are moderate, but the difference between the northern and southern sections during this season is greater than during the summer. The amount of snow that falls is light and seldom remains on the ground longer than a few hours. The rains principally fall during the months of July, August, and September, but the annual amount is small, seldom exceeding a few inches. When there are heavy snows in the mountains during the winter, there will be good crops the following summer, the supply of water being more abundant, and the quantity of sediment carried down greater than when the snows are light. Good crops appear to come in cycles, three or four following in succession, then one or two inferior ones. During the autumn months the wind is disagreeable in some places, especially near the openings between high ridges, and at the termini of or passes through mountain ranges. There is, perhaps, no healthier section of country to be found in the United States than that embraced in the boundaries of Colorado and New Mexico. In fact, I think I am justified in saying that this area includes the healthiest portion of the Union. Perhaps it is not improper for me to say that I have no personal ends to serve in making this statement, not having one dollar invested in either of these Territories in any way whatever. I make it simply because I believe it to be true. Nor would I wish to be understood as contrasting with other sections of the Rocky Mountain region, only so far as these Territories have the advantage in temperature. It is possible Arizona should be included, but as I have not visited it I cannot speak of it. There is no better place of resort for those suffering with pulmonary complaints than here. It is time for the health seekers of our country to learn and appreciate the fact that within our own bounds are to be found all the elements of health that can possibly be obtained by a tour to the eastern continent, or any other part of the world. And that, in addition to the invigorating air, is scenery as wild, grand, and varied as any found amid the Alpine heights of Switzerland. And here too, from Middle Park to Las Vegas, is a succession of mineral and hot springs of almost every character.

The productions of New Mexico, as might be inferred from the variety of its climate, are varied, but the staples will evidently be cattle, sheep, wool, and wine, for which it seems to be peculiarly adapted. The table-lands and mountain valleys are covered throughout with the nutritious gramma and other grasses, which, on account of the dryness of the soil, cure upon the ground and afford an inexhaustible supply of food for flocks and herds both summer and winter. The ease and comparatively small cost with which they can be kept, the rapidity with which they increase, and exemption from epidemic diseases, added to the fact that winter feeding is not required, must make the raising of stock and wool-growing a prominent business of the country; the only serious draw-back at present being the fear of the hostile Indian tribes. But as these remarks apply equally well to all these districts, I will speak further in regard to this matter when I take up the subject of grazing in this division.

The cattle and sheep of this Territory are small, because no care seems to be taken to improve the breed. San Miguel County appears to be the great pasturing ground for sheep, large numbers being driven here from other counties to graze. Don Romaldo Baca estimates that between five hundred thousand and eight hundred thousand are annually pastured here; about two-thirds of which are driven in from other sections. His own flocks number between thirty thousand and forty thousand head; those of his nephew twenty-five thousand to thirty thousand; Mr. Mariano Trisarry, of Bernalillo County, owns about fifty-five thousand; and Mr. Gallegos, of Santa Fé, nearly seventy thousand head.

Don Romaldo Baca stated to me that his flocks yielded him an annual average of about one and a half pounds of washed wool to the sheep; that the average price of sheep was not more than two dollars per head; that the wool paid all expenses and left the increase, which is from fifty to seventy-five per cent. per annum, as his profit. From these figures some estimate may be formed of what improved sheep would yield.

Wheat and oats grow throughout the Territory, but the former does not yield as heavily in the southern as in the northern part. If any method of watering the higher plateau is ever discovered, I think that it will produce heavier crops of wheat than the valley of the Rio Grande.

Corn is raised from the Vermijo on the east of the mountains around to the Culebra on the inside; in fact, it is the principal crop of San Miguel County, but the quality and yield is inferior to that which can be produced in the Rio Grande Valley, and along the Rio Bonito. The southern portion of the Rio Pecos Valley and the Canadian bottoms are probably the best portions of the Territory for this cereal.

Apples will grow from the Taos Valley south; but peaches cannot be raised to any advantage north of Bernalillo in the central section, but it is likely they would do well along some of the tributaries and main valley of the Canadian River. They also appear to grow well and produce fruit without irrigation in the Zuñi country; and the valley of the Mimbres is also adapted to their culture. Apricots and plums grow wherever apples or peaches can be raised. I neglected to obtain any information in regard to pears, but judging from the similarity of soil and climate here to that of Utah and California, where this fruit grows to perfection, I suppose that in the central and southern portions it would do well. The grape will probably be the chief or at least the most profitable product of the soil. The soil and climate appear to be peculiarly adapted to its growth, and the probability is that as a grape-growing and wine-producing section it will be second only to California. From Colonel McClure I learned that the amount of wine made in 1867 was about forty thousand gallons, and that the crop of 1869 would probably reach one hundred thousand gallons; I have not been informed since whether his estimate was verified or not. A good many vineyards were planted in 1869, at least double the number of 18,8. Several Americans, anticipating the building of a railroad through that section, have engaged in this branch of agriculture. The wine that is made here is said to be of an excellent quality.

Beets here, as in Colorado, grow to an enormous size, and it is quite likely that the sugar beet would not only yield heavy crops, but also contain a large per cent. of saccharine matter. I am rather inclined to believe that soil which is impregnated with alkaline matter will favor the production of the saccharine principle. I base this opinion wholly on observations made in Utah in regard to its effect on fruit, therefore experiments may prove that I am wholly mistaken. It is possible the experiment has been tried; if so, I am not aware of it.

The Irish potatoes are inferior to those raised farther north. Cabbages grow large and fine. Onions from the Raton Mountains south have the finest flavor of any I ever tasted, and therefore am not surprised that Lieutenant Emory found the dishes at Bernalillo "all dressed with the everlasting onion." But as to the "chili" or pepper which is so extensively raised and used in New Mexico, I beg to be excused, unless I can have my throat lined with something less sensitive than nature's coating. Sweet potatoes have been successfully tried in the vicinity of Fort Sumner and along the head-waters of the Rio Bonito. Melons, pumpkins, frijoles, &c., are raised in profusion in the lower valleys; and I understand cotton was formerly grown in limited quantities.

As a general thing the mountains afford an abundance of pine for the supply of lumber and fuel to those sufficiently near to them. Some of the valleys have a limited amount of cottonwood growing along them. In addition to pine, spruce and cottonwood, the stunted cedar and mesquit, which is found over a large area, may be used for fuel. The best timbered portion of the Rio Grande Valley is between Socorro and Doña Aña. The east side of the Guadalupe range has an abundant supply of pine of large size. Around the head-waters of the Pecos is some excellent timber. Walnut and oak are found in a few spots south, but in limited quantities and of too small a size to be of much value.

THE CANADIAN SECTION.

This section, in a strictly systematic arrangement, would be included in the Arkansas district, to which it really belongs; but, for convenience, and that the plan of my report of last year may remain unchanged, I describe it separately. It includes that part of New Mexico lying between the Raton Mountains on the north and the Pecos section, or

"Llano Estacado" on the south and southwest, and contains about fourteen thousand square miles. The amount of arable land in this section, as heretofore stated, is estimated at about one thousand four hundred square miles, or nine hundred thousand acres. This estimate is made on very slender data, and therefore cannot be considered as very reliable, but I am satisfied that it is not too large, and I think it is approximately correct.

The Canadian River, rising in the Raton Mountains, runs southeast for about one hundred and fifty miles, to Fort Bascom, where it turns east, and passes out of the Territory, a little north of the thirty-fifth parallel—its whole length within the limits of the Territory being about two hundred miles. Most of its tributaries of any importance in an agricultural point of view flow in from the west, of which the following are the principal ones: Vermijo, Little Cimarron, Ocate, Rayada, (a branch of the Ocate,) Moro, Rio Conchas, Pajarito Creek, and Tucumcari Creek.

As will be seen by a glance at the map of this region, its western part slopes eastward, while the general descent is toward the south. Hence the highest portion of its general surface is found in the northwest angle, where the elevation is probably about five thousand feet above the sea-level, while the southeast corner, which is the lowest, has an elevation of only three thousand feet.

The fall of the river, from the mouth of Pajarito Creek east for about two hundred miles, is about nine feet to the mile. The fall above this is unknown, but it is evidently greater. It is therefore evident that the amount of land which can be irrigated is limited only by the supply of water, which is somewhat uncertain. I know but little in regard to the valley of this river, but understand that, as a general thing, it is not extensive; that at many points the bluffs press closely upon it, leaving but a narrow opening for the river, while at others they recede, leaving broad and fertile bottoms. The bordering plains are generally quite sandy, supporting but a scanty vegetation. The landscape is varied by small elevated mesas rising from the comparatively level surface, whose sharp outlines form a singular feature of this country.

The following description of the western border, across which our expedition passed in 1869, will give a tolerably correct idea of the section:

Starting from the crest of the Raton Mountains, immediately above the source of the Canadian River, after passing down through a dense forest of magnificent pines and firs, we enter a beautiful little valley covered over with a thick sward of luxuriant grass. Here a considerable amount is annually cut for hay and taken to Trinidad. But this valley soon terminates, and the little stream and road enter a rugged cañon bordered by precipitous bluffs of gray sandstone, which continue to the plains at the base of the mountain. Here a grand panoramic view spreads out toward the south; a broad, valley-like plain slopes southward as far as the vision will reach. Scarcely a tree or shrub is to be seen; all is one smooth, grassy carpet, which, on the distant gentle slopes, looks more like pale, pea-green velvet than anything else to which I can compare it. Rising up from the broad base are two or three huge basaltic tables, lifting their perfectly level surfaces one hundred and fifty feet or more into the air, and all clothed in the same velvety covering, but which fails to destroy the sharp outline of circular rim. The little stream, like a silvery thread, is seen winding its tortuous course along the gently descending plain, joined now and then by a slender rill flowing down from the mountain on the west. It is a magnificent pasture ground for sheep and cattle, where thousands might be grazed and tended with but little trouble. But the stream is too small to irrigate any great extent of the lands through which it passes, and which could easily be reached if the supply of water was sufficient; yet enough can be obtained to supply the wants of a moderate pastoral settlement.

The first tributary we reach that will afford means of irrigation is a small stream that flows in from the northwest along the base of the variegated mural boundary that hems in the landscape on the west. I believe it is called Uria. It has some very pretty bottoms, which are quite fertile and can be easily irrigated to the full capacity of the stream, which is but a few feet wide and a few inches deep.

The Little Cimarron and Vermijo afford considerable breadth of arable land, the former presenting a valley some twenty-five or thirty miles long, varying in width from one to six miles, which can be easily irrigated. The latter presents a valley of more uniform width, and bordered, generally, by higher lands. It is about the same length as the former, and where we crossed it about two miles wide, and very rich and fertile, the creek supplying sufficient water to irrigate the whole of it.

The Rayada runs through a valley somewhat similar to that of the Vermijo, the bottoms being very low and easily irrigated, but I think they are subject to occasional overflows. The creek is sufficient to supply the lower level with water for irrigation, but the second level is rather too high to be reached except by a lengthy canal.

The Ocate winds through a narrow valley of erosion, the high bordering bluffs descending to it in steep curves, beautifully carpeted over with grass. Not a tree or bush is to be seen; all is as smooth as a meadowy lawn. The part of this valley which I visited is narrow, varying from one-half to a mile or so in width, but it may expand as it approaches the river.

The Moro Valley is the finest in this section, and, next to the Taos Valley, the best wheat-growing region in the Territory. The upper or mountain portion of it is some eight or ten miles long and about three miles wide. After passing out of this through a narrow gorge, the creek enters the more open plains, and is bordered for the greater part of its length by a tolerably broad and very fertile valley. The entire length is, perhaps, some sixty or seventy miles, and the width of the irrigable lands that skirt the creek will probably average four or five miles.

As the topography of this portion of the section has been somewhat minutely described by Dr. Hayden, (see Preliminary Report, 1869, pp. 56–61,) it is unnecessary for me to repeat it here.

The comparatively low elevation and southeastern exposure of this section, together with the mountain barriers west and north, give to it a more moderate climate than that of the section immediately west. Not only is wheat which is produced here remarkably fine, but maize grows large, with full, fine ears. The fruits, if cultivated, would produce crops almost, if not quite, equal to those of the Rio Grande Valley. And in the southeast part of the section, along the Canadian River, grapes can be grown without any difficulty. The native grape, without having the aid of irrigation, grows here in rich profusion, the stunted vines often being loaded down with the clusters.

As heretofore intimated, the western border affords some of the finest grazing fields in the Territory, especially for sheep.

THE ARKANSAS DISTRICT.

This district includes that part of Colorado Territory situated between the "Divide," opposite South Park, and Raton Mountains, and lying east of the dividing ridge of the Rocky Mountains. It not only embraces the plains east of the base of the mountains, but also the Upper Arkansas Valley or park lying within them. It contains about twenty-six thousand square miles, of which about one-fourth, or six thousand square miles, can be irrigated and brought under cultivation. It is being rapidly settled up, and will ultimately prove to be the richest agricultural portion of the Territory.

The Arkansas River, rising a little northwest of South Park, runs southeast nearly to Poncho Pass, where, turning a little more toward the east, it passes through a cañon for about forty miles, emerging upon the open country at Cañon City. From this point to the eastern boundary of the Territory it runs almost directly east.

The mountain valley has an elevation of between seven and eight thousand feet above the sea, while that of the plain country lying east of the range varies from six thousand near the base of the mountains to about three thousand five hundred feet at the eastern boundary of the Territory. This somewhat rapid descent of the plains eastward is a very important item in estimating the agricultural capacity of this country; for it was for some time a serious question in my mind whether the descent on the broad open plains was sufficient, after leaving the mountains for some distance, to carry the water of these rivers over the sandy soil; but from a list of elevations along the Kansas Pacific Railroad, kindly furnished Dr. Hayden by General Anderson, superintendent of that road, I learn the following important facts: That from Denver to Fort Hays, a distance of three hundred and forty-seven miles, the fall is three thousand two hundred and seven feet, or a little over nine feet to the mile, showing it possible to pour the waters of the South Platte into the channel of Smoky Hill River. From Cheyenne Wells, near the source of the Smoky Hill River, to the same place, a distance of one hundred and seventy-three miles, the fall is one thousand two hundred and eighty-three feet, or over seven feet to the mile, which is sufficient to carry the water upon levels sixty, or even one hundred, feet above the stream, where the supply is sufficient. The Arkasas River, from the mouth of the Apishpa to the mouth of the Pawnee, a distance of two hundred and six miles, has the remarkable fall of two thousand four hundred and eight feet, or more than eleven feet to the mile. This is sufficient to reach the highest extensive levels, so that, east of Pueblo, the extent of the irrigable land is limited only by the supply of water, which confirms an opinion expressed by Mr. Byers in a communication to me concerning this valley.

The head-waters of the Arkansas are in an oval park situated directly west of the South Park. The altitude of this basin is probably between eight and nine thousand feet above the level of the sea; the length is about fifty miles from north to south and twenty or thirty miles in width at the middle or widest point. At the lower or southern end, an attempt has been made to cultivate the soil, which bids fair to prove a success. Around the Twin Lakes, at the extreme point, oats, wheat, barley, potatoes, and turnips have been raised, yielding very fair crops. Below this basin the river, for twenty miles, passes through a narrow cañon, along which, with considerable difficulty, a road has been made. Emerging from this, it enters the "Upper Arkansas Valley" proper, which is a widening of the bottom lands from two to six or eight miles. This valley is some forty or fifty miles in length and very fertile. Near the southern extremity are some large boulder deposits, evidently formed during its lake period, ere the southeast barrier had broken away before the accumulated waters. The chief portion of the arable land lies on the west side of the stream, which generally hugs closely the base of the eastern range.

Several streams of moderate size flow down from the Sahwatch range on the west and cross the main valley. The largest of these is the South Arkansas, up which an arm of the park or valley extends for several miles. The average elevation is about seven thousand feet above the level of the sea. There is already a considerable population there, two or three small villages, a flouring mill, and at least one hundred farms.

Although somewhat elevated, this region is well protected from the winds by the lofty mountain wall that hems it on every side, and stock can be kept on the grazing fields most of the winter, shelter and feeding being but seldom required, and that but for a short time. Passing through here in October, 1869, we found it clear of snow and the weather pleasant. We also procured here some of the finest potatoes I saw while in the Territory. The extent of irrigable land may be estimated, in the entire basin, at three hundred square miles.

Below this the mountains and hills again crowd down to the river, leaving only a few small openings suitable for settlement. But, as is generally the case with these little mountain valleys in this portion of the country, they are very fertile.

It is probably forty or fifty miles from the lower end of this valley to Cañon City, where the river leaves the mountains. From this point to Pueblo, which is situated at the mouth of the "Fountaine Qui Bouille," the distance is forty miles. The valley of the river during this part of its course is very uneven and broken. At one point the bottom will spread out for five or six miles in width; then again it is shut in by rolling hills or elevated plateaus. Mr. Byers estimates the irrigable lands in this part of the valley at two hundred square miles. But I am inclined to think these elevated plateaus are not beyond the reach of irrigation from the river. Take, for instance, the one immediately south of Cañon City, which, according to my present recollection, is about one hundred and twenty-five or one hundred and fifty feet above the water level; with the fall the river has in this part of its course, which cannot be less than fifteen feet to the mile, I see no reason why the water could not be carried upon it. But it is possible Mr. Byers includes these in his estimate, which certainly is not extravagant.

From Pueblo eastward the valley is wide, with easy slopes right and left to the elevated plains, much like the valley and bordering lands of the South Platte. Therefore we may safely assume that, with a fall of eleven feet to the mile, which the river has in this part of its course, the extent of land which may be irrigated is only limited by the supply of water. Starting from Pueblo with a width of two or three miles, there is nothing to prevent widening the belt to thirty or forty miles, thus giving between Cañon City and the eastern boundary of the Territory at least four thousand square miles, or two millions and a half acres of irrigable land.

The fact that a large quantity of the water of a stream like this sinks out on the plains, should not be set down as conclusive evidence that the bordering lands cannot be irrigated from it; for, in the first place, they generally have much more water in them during the season of the year when irrigation is necessary than in the latter part of the summer and fall, when not required. And in the second place, all the water that comes down from the mountains may be retained on the surface by tapping the streams above the point where it sinks. Suppose all the water which flows down from the mountains in the Arkansas and its numerous tributaries was gathered into canals and equally distributed over the broad plains of this part of the Territory, who will dare say that four thousand square miles, yea almost twice four thousand, might not be irrigated? Then the simple point to be determined is, can this be done? I believe it can, and that when the demand for land in this district requires it, it will be done; the great obstacle here, as elsewhere in these Territories, being to bring together that amount of capital or force sufficient to construct these canals at a reasonable cost per acre.

The principal tributaries of the Arkansas that flow in from the south, east of the mountains, are Hardscrabble and Greenhorn Creeks, (the St. Charles is a branch of the latter,) Huerfano River, which has a large tributary named Cuchara; Apishpa River, Timpas Creek, and Purgatory River. On the north side, Fountain Qui Bouille River and Squirrel Creek are the principal streams affording water.

Hardscrabble is a small stream running through a broken section, and is skirted by narrow bottoms from a half to two miles in width, which are low, easily irrigated, and quite fertile. The St. Charles is a larger stream, which traverses some arable lands, but is occasionally hemmed in by bluffs. As I crossed it only at a deep, narrow cut, I am unable to speak positively in regard to the extent of its valley, but I understand considerable bodies of irrigable land are to be found along its course, and that near its source is a valley of moderate size called Wet Mountain Valley, which affords some good farming land. The Greenhorn Valley also furnishes level land and irrigating facilities sufficient for considerable agricultural settlements. The length of this valley is probably thirty miles, but what its average width is I do not know. Along the Huerfano and its chief tributary are some of the best farming lands in the district. Huerfano Park, or, as it is sometimes called, the Upper Huerfano Valley, which lies west of or behind the Wet Mountains, is about fifteen miles long and from three to five miles wide, and is already tolerably well settled. The valleys of these two streams are of moderate width, but are occasionally interrupted for some distance by the upper level, which presses close upon the streams, leaving only deep cuts or cañons. But as the fall is rapid, the water could, without much difficulty, be brought upon the upper surface, thus largely increasing the amount of tillable lands. Where we crossed the Cuchara, the bottom was about one mile wide, but the second level, which is extensive, was not more than fifty feet above the stream, and, as I learn, is generally less than this height.

In regard to the valley of the Purgatory I know but little, as I did not have an opportunity of visiting it. Its upper portion, I believe, is narrow, and occasionally the bluffs close in upon the stream for several miles; but the lower moiety is broader, affording room for extensive settlements. There is, I believe, as a general thing, an ample supply of water for irrigating purposes, but during the latter part of the season the flow becomes somewhat scanty.

Monument Creek, from its source to where it enters the Fountaine Qui Bouille, is about twenty-four miles long, and affords water sufficient to irrigate an average of only half a mile on each side. For a part of its course it runs through forests of pine, where the growth is tall and fine and well suited for lumbering purposes. The Fountain Qui Bouille, which rises in the mountains northwest of Colorado City, has a run of about fifty miles, the immediate valley averaging about two miles. The plains which flank it are generally of but moderate height and slope down gently, and can be irrigated, with but little difficulty, to the full extent of the water in the stream.

This entire district affords broad and extensive grazing fields for cattle and sheep, and quite a number of herders and stock-raisers are beginning already to spread out their flocks and herds over these broad areas of rich and nutritious grasses. One of the finest meadows, of moderate extent, that I saw in the Territory, was on the divide near the head of Monument Creek, and near by was a large pond of cool, clear water.

The temperature of this section is somewhat similar to that of Northern Missouri, and all the products grown there can be raised here, some with a heavier yield and of a finer quality, as wheat, oats, &c., while others, as corn, yield less and are inferior in quality.

An experiment made by Mr. John T. Smith, a short distance south of Cañon City, proves conclusively that such fruits as apples, peaches, pears, and cherries will grow here without difficulty, and produce abundant crops of excellent quality. I saw here peach trees in fruit the fourth year from the seed.

SOUTH PLATTE DISTRICT.

As my report of 1869 covered this district, I will only add such additional facts in regard to its agricultural prospects and development as I gathered the present year. The impetus given to the settlement and cultivation of this district by the completion of the Kansas Pacific and Denver Pacific Railroads is already manifest. At the mouth of the Cachè a la Poudre, where last year only a ranch or two were to be seen, is now a fine village. Farms are marked off in the valley and on the plains, and extensive preparations made to test on a broad scale, next season, the productive powers of this soil. A canal some fourteen or fifteen miles long has been commenced and will shortly be completed. This will bring water from the Cachè a la Poudre and afford means of irrigating some fifty or sixty thousand acres of the plains that lie north of the Platte. And, if I am not wholly mistaken, that which has by some been ridiculed as a barren cactus plain will produce crops of cereals that will rival the heaviest yield of the richest lands of the States. I may be mistaken, but will cling to the opinion, until contradicted by fair experiments, that the uplands or ridges of this section, when properly irrigated and cultivated, will produce better wheat than the creek bottoms.

The Kansas Pacific Railroad Company contemplate running a canal from the mouth of Platte Cañon to some point near the head-waters of the Republican Fork, a distance of one hundred and forty or one hundred and fifty miles. The rise between Bijou and Denver Junction may present some difficulty, but this can doubtless be overcome by bending round to the north, where the elevation is less. And the fall between the mouth of the cañon and Denver, which is probably two hundred feet or more, may considerably lessen the flexure. If this great work is completed we may see ere long the irrigated lands brought close to the rain-moistened region; a belt of farms stretching from the Missouri River to the Rocky Mountains. Such a consummation is certainly desirable. The "Great American Desert" belted with fields of golden grain and pleasant homes would be a result not anticipated ten years ago, and the very mention of which is ridiculed by many now, but which those who carefully study the country do not concede as impossible.

NORTH PLATTE DISTRICT.

The boundaries of this district are more difficult to describe than those of either of the other districts of the eastern division. Not because they are any less definite, but because the water-sheds at some points are not prominent, and have received no well-known and fixed names. The following lines will designate the area embraced in the district with sufficient accuracy for present purposes:

Commencing at Long's Peak, it runs west, and then north, leaving the North Park to the right; from thence northwest, by way of Bridger's Pass and Creston Station, it crosses over the plains to South Pass. From this point it runs northeast between Little Popoagie and Sweetwater, and passes round the Rattlesnake Hills between Bad-Water and Poison Spring Creeks. From here, turning east, it passes along an irregular range of hills to the southern extremity of the Big Horn Mountains; then, turning southeast, passes between the waters of the Cheyenne and North Platte Rivers to the eastern boundary of the Territory. Following the boundary line of the Territory southward, we may properly include Lodge Pole Valley, as its upper portion appears to belong more to the North Platte slope than that of the South Platte.

These boundaries embrace an area of about twenty-five thousand square miles, and, exclusive of North Park, nearly one-fourth of Wyoming Territory. With the exception of a few small sections, they include the most desirable portions of the Territory, and the greater part of the arable lands.

This district is not only very irregular in its outline, but bears the same varied and irregular character interiorly. The mighty convulsive force which heaved up these vast Rocky Mountain ranges seems to have obtained slight breathing places for its imprisoned energies at the parks of Colorado, while here, with one terrific throe, it has scattered the mountains and hills in wild confusion as a giant would scatter pebbles. In the eastern portion, stretching north and south, is a range of rough and lofty mountains, which, at its northern extremity, is rent into fragments and scattered in decreasing peaks and ridges to the northwest. Along the southern border, turning in nearly every direction of the compass, are lofty ranges whose summits wear crowns of perennial snow. Westward the mountain ranges trending northwest sink beneath the immense deposit of local drift, which here covers the mighty chasm, but they show themselves further north in the granite peaks, which, like islands, shoot up from the Sweetwater Plains, and further on emerge in the Wind River range. Between these irregular surroundings lie the broad Laramie Plains, which might appropriately be called the Great Park of Wyoming. Entirely east of the Black Hills we enter upon the plains which slope toward the Missouri River.

The area west of the Black Hills, as shown by the course of the streams, and also by the barometer, slopes north and east, pouring its waters through the northeast angle of the district. The average level of the entire district is higher than that of either of the others of this division, the western portion being on an average about six thousand five hundred feet above the level of the sea. The difference of level between the North Park and the mouth of the Sweetwater is about two thousand feet; and between South Pass and the mouth of the Sweetwater about one thousand five hundred feet. The area east of the mountains varies from four thousand four hundred to six thousand feet above the sea level.

On account of its altitude, and the direction and force of its atmospheric currents, the temperature of this district is lower than that of the other districts east of the divide, within the bounds under consideration. And as a general thing only those products adapted to a cold climate and short seasons can be raised to any advantage. Yet it is exceedingly important to know, not only that a mining section can produce the principal cereals, as wheat, oats, and barley, and the more useful vegetables sufficient to supply its own wants, but also to know something in regard to the locality and extent of its arable lands. A few acres of productive soil in the vicinity of a rich mine will often yield a greater profit to the cultivator than a large farm in Ohio or Illinois.

It is difficult to give any very reliable estimate of the land susceptible of cultivation in the bounds of this district, as much of it is in small bodies of irregular shape; yet I think that by proper efforts at least three thousand square miles, or about two million acres, can be brought under cultivation. This may be thought an exaggerated estimate, when we take into consideration the large proportion of the area occupied by mountains, the barren tract south of the Sweetwater, and the deficiency in the supply of water on the plains east of the Black Hills. But when more effectual means of husbanding the water are adopted, as by tapping the streams nearer their exit from the mountains, and keeping it above the surface, by forming reservoirs, &c., the supply will be found greater than at present supposed, and the estimate given, instead of being too large, will most likely prove to be too small. The cold climate, it is true, is a serious obstacle, yet there are but few arable spots in the district that cannot be made to produce useful crops of some kind.

The district is naturally divided into four sections, as follows: The North Park, the Laramie Plains, the Sweetwater region, and the plains lying east of the Black Hills, forming, as it were, a winding series of vast steps from the mountain height to the broad plains below.

NORTH PARK.

This elevated mountain basin, in which the North Platte takes its rise, lies entirely within the bounds of Colorado Territory. It is about fifty miles long from east to west, and thirty miles wide from north to south, containing a surface area of some eight or nine hundred square miles. The elevation varies from seven thousand five hundred feet to nine thousand feet above the level of the sea, the average being about eight thousand feet.

The following description of this mountain cove, from a former report made by Dr. Hayden, will convey a better idea of it in a few words than any description of my own. And, although several years have passed since it was made, and glowing descriptions have since been published, there seems to be nothing new added:

> The North Park is oval or nearly quadrangular in shape. Viewing it from one of the high mountains on its border, it appears like a vast depression which might once have formed the bed of a lake. Its surface is rather rugged, yet there are broad bottoms along the streams, especially the North Platte and its branches. Scarcely a tree is to be seen over the whole extent, while the mountains which wall it in on every side are dotted with a dense growth of pine. The grass grows in the park quite abundantly, often yielding at least two tons to the acre. Streams of the purest water flow through the park, and there are some of the finest springs I have seen, a few of them forming good-sized streams where they issue from the ground. I am quite confident that this entire park would make an excellent grazing region for at least six or eight months of the year. The soil is very rich, but the seasons must be too brief for the successful cultivation of any crops. Indeed, there is frost there nearly every night, and snow falls every month in the year. On the north and east sides may be seen the snow-covered ranges rising far above all the rest, their summits touching the clouds. On the west side there is also a short snowy range. On the west side long ridges come into the park and die out in the plain, forming a sort of *en echelon* arrangement.

The soil is mixed with gravel and coarse sand on the ridges and upper levels, but along the bottoms that flank the streams is rich and dark. On the north side there is a quite sandy area. If future experiments should prove that it is possible to raise valuable crops here, there will be no difficulty in bringing the land under cultivation so far as the supply of water is concerned, for this is ample, and the fall sufficient to irrigate all the lands which can be cultivated. It may be thought visionary to speak of agriculture in this elevated, snow-bound cove, and the remarks quoted imply that Dr. Hayden, with all his experience in this region, looks upon it as impossible. But it is not best to conclude too hastily, for if a number of rich mines should be discovered here and worked for a few years, the demand for fresh vegetables might bring about, in practice, that which is considered impossible in theory. At least the scope of my plan requires me to give an account of the arable areas, and the facts in regard to the seasons, so far as known, leaving the battle with climate to be determined by experiments.

And it is possible that a record of the seasons may show that it is really no colder here than in South Park, which has a greater elevation than this park, and is also partially surrounded by snow-covered mountains; but, as remarked in the introduction, latitude and elevation do not always determine the climate in the Rocky Mountain regions. Be this as it may, there is here a fine grazing field for cattle and sheep, but these would require some feeding and occasional sheltering during the winter months. Nature has provided amply the means to meet every necessity in this direction; from the grassy valleys, at a nominal cost, all the hay necessary could be cut; the mountain sides are bristling with sturdy pines, and the rapid streams as they rush down from their fountains afford all the power necessary to drive mills to saw the lumber. Of course, places requiring this trouble and expense will not be selected while others equally good, which do not require it, can be easily found.

The North Platte, from its point of exit from the park to where it reaches the border of Laramie Plains, passes through a rugged, mountainous region. Along the upper portion of its course its valley is very narrow, sometimes amounting to nothing but a gorge. But as it descends toward the northwest it is joined by several small tributaries, and its valley widens, affording occasionally bottoms of moderate breadth, especially near the entrance of Sage Creek, where there is a considerable stretch of fine wooded bottoms.

LARAMIE PLAINS.

This section is bounded on the east and northeast by the Black Hills, on the west by the West Rattlesnake Hills, and on the southwest by Medicine Bow Mountains. It is somewhat quadrangular in shape, its average length from southeast to northwest being about ninety miles, and average width from northeast to southwest about seventy-five miles, containing (exclusive of the surrounding mountains) a surface area of about six thousand seven hundred and fifty square miles, or nearly four million five hundred thousand acres. It is drained chiefly by the Medicine Bow and Laramie Rivers and their tributaries, both affluents of the North Platte, which also traverses the extreme western border. The Laramie, rising in the mountains at the southwest angle, flows along the eastern border to the northeast angle of the section, where it breaks through the Black Hills and joins the North Platte in the plains beyond. The Medicine Bow, receiving affluents from each side, but principally from the south, flows through the western part of the section and joins the North Platte on the western border; which latter stream makes its exit at the northwest angle.

The surface varies considerably in character and elevation, some of it presenting beautiful meadowy expanses, while other portions are rolling and hilly and but sparsely covered with vegetation. The average elevation, as before stated, is about six thousand five hundred feet above the level of the sea; but, as will be seen below, different parts vary in height as much as one thousand seven hundred feet, counting from the water levels. As most of the streams in this section afford an ample supply of water during the season when it is most needed for irrigation, their fall becomes an important item in making up an estimate of the cultivable lands. I therefore give the levels of the principal points of the three larger. The North Platte at the railroad crossing has an elevation of six thousand four hundred and seventy-seven feet, and at the mouth of the Sweetwater nearly six thousand feet above the level of the sea, showing a fall in this distance of about four hundred and eighty feet, or seven feet to the mile. Medicine Bow River at Medicine Bow Station has an elevation of six thousand six hundred and ninety-eight feet, and at its junction with the Platte about six thousand three hundred feet, a difference of nearly four hundred feet, or about eight feet to the mile. Laramie River at Laramie City is seven thousand one hundred and twenty-three feet above the level of the sea, and at the point where it enters the Black Hills about five thousand four hundred feet, a difference of over one thousand seven hundred feet, giving the very rapid fall of eighteen or twenty feet to the mile.*

These figures develop the important fact that not only the bottoms, but also the upper levels, except where they are very high, can be irrigated. This must increase our estimate of the cultivable lands of the section to an amount considerably beyond the area of the immediate bottoms.

The southeast part, to which the name "Laramie Plains" is sometimes limited, is decidedly the best portion of the section, and contains much the largest proportion of arable land. Counting from the head of the Laramie Valley to Rock Creek it is about seventy miles long, with an average width of about twenty-five miles, giving an area of seventeen hundred and fifty square miles. Although the west end of this area contains the dividing ridge between the Medicine Bow and the Laramie, yet I think we may safely estimate that one-half of it can be irrigated and brought under cultivation. The greater portion of this beautiful valley is covered with a rich growth of grass, and presents the appearance of one broad meadow, over which the numerous herds of cattle which are being gathered here to graze can be seen roaming. The western part of this sub-section beyond Cooper's Lake presents a barren appearance until we reach the vicinity of Rock Creek. The creek, although bordered by occasional bluffs, during most of its course is margined by fertile bottoms of moderate width, and tolerably well timbered along its upper portion. Some of the southern tributaries of Medicine Bow pass through fertile valleys, which can be easily irrigated and brought under cultivation. The main stream passes for some distance between rocky bluffs, with small bottoms on the alternate sides, but is generally flanked by a moderately wide valley, with here and there groves of cottonwood. I have not visited the valley of this stream or that of the North Platte, north of the railroad, but from the information obtained in regard to them, believe that by proper efforts they would afford a considerable extent of tillable land. I have seen only a

* The elevations along the railroad are taken from the survey of that road. The others are estimates made up from the barometric record kept by Mr. Beman during the geological survey of the present season (1870,) and which he very kindly copied and furnished me while in the field.

part of the northern extension of the Laramie Valley, but judging from that, and its rapid fall and the general features of the surrounding country, I am satisfied that not only the bottoms, but that a large amount on the lower ridges and plateaus may be irrigated and cultivated. But I am inclined to think that along a part of its northern course the bordering regions are quite broken, and that the belt of arable land there is small. The northwest angle of the section is also probably quite broken and uneven, affording very little arable land.

The climate, as might be inferred from the elevation and surroundings of this basin, is somewhat severe, and the seasons short. But the greatest drawback does not appear to be from these causes taken generally, but from the occasional untimely frosts and gusts of snow which nip the growing crops in the spring, or injure them later in the season when nearly matured. The cold nights, as is generally the case in these high regions, retard the growth especially of the cereals. Yet, notwithstanding these drawbacks, the repeated experiments made during the past four years have shown conclusively that useful crops can be raised here.

I visited Laramie City August 3, for the purpose of examining the garden of Dr. Latham, who has charge of a military hospital at this place, and who is experimenting with various vegetables and cereals in order to ascertain what can be raised here. I found this garden to be quite extensive and in a flourishing condition. Here I saw a small piece of barley, full-headed, well stooled, and of medium height; also a similar piece of wheat, which, though sowed late, presented a very fine appearance. The potatoes and turnips were remarkably fine. Peas grow very large and thrifty, as I can testify from the excellent ones I ate at the doctor's table, and which I saw gathered from the vines in his garden. His beets were making a vigorous growth, as were also the following vegetables: winter squashes, cabbages, beans, lettuce, onions, carrots, radishes, &c. I pulled some turnips in another field, which were at least six inches in diameter, the seed from which they grew having been sown the 15th day of May. The tops were remarkably large and succulent. I did not have time to visit the garden under charge of the officers stationed at Fort Sanders, but I understood it was in a flourishing condition. These experiments, as I learn from a former report made by Dr. Hayden, were commenced about 1866 by General Gibbon, and have, with commendable zeal, been continued by the officers in command of the post.

Oats appear to grow and mature wherever tried in the valley.

These experiments, and others made along Laramie River, Rock Creek, and at other points, continued as they have been for several years, certainly settle the question as to the practicability of farming in the Laramie Plains. The points where they have been made are the highest on the Plains, and, I am rather inclined to believe, the coldest portion.

Although this section may not be an agricultural region in the broader sense of the term, yet its situation renders it a matter of deep interest to know that the hardier vegetables, and such cereals as wheat, oats, and barley, can be raised here; for, placed in the center of the mountains, on the great thoroughfare between the Atlantic to the Pacific, with a broad barren plain to the west, and a mountain stretch to the east, it is very desirable to have here a halting place.

The business of the road necessary at the termini of divisions, stock-raising, temporary grazing of passing herds, lumbering, and probably coal-mining, will bring here a considerable population.

There is perhaps no finer grazing section in Wyoming than this. The southeastern part is literally carpeted over with a compact growth of rich and nutritious grasses, which the water of the numerous little streams that sweep down from the mountains keeps constantly fresh. And the rain-fall, I judge, is greater here than in any other part of the Territory, and it seems to be on the increase, which also appears to be true around Cheyenne. I understand that stock can be wintered here without shelter and with very little feeding; in fact, large flocks of sheep and herds of cattle, as will hereafter be shown, have passed the winter with no other feed than the uncut grass of the valleys and plains. Hay in abundance can be obtained along the creek bottoms at a nominal cost. Dr. Latham informed me that his hay cost him this season, in the stack where it was cut, but $3 per ton.

Timber, such as pine and fir, of an excellent quality, can be obtained from the mountains along the southern border. A vast quantity is annually cut and floated down the Little Laramie and other streams for lumber, railroad ties, &c. Some of the streams, especially along the southwest border, are margined by groves of cottonwood, which will furnish fuel and fencing material for that locality.

THE SWEETWATER REGION.

I cannot define this section better than by saying that it includes the valley and bordering plains through which the Sweetwater River passes, from the vicinity of South Pass to its junction with the North Platte. This stream rises a little northwest of the pass, and flows almost directly east about one hundred and thirty miles, connecting with the North Platte near the exit of the latter from the Laramie Plains. For about twenty-five or thirty miles east of the pass, it flows through a rugged, mountainous region, falling rapidly, and presenting no areas of importance that can be brought under cultivation. A short distance west of St. Mary's Station it bursts from its mountain cañons, and enters upon a valley that continues, with some short interruptions, throughout its course. The comparative uniformity of this valley will obviate the necessity of any lengthy description of the different sections of it.

Beginning at South Pass, (on the summit,) with an elevation of seven thousand four hundred and ninety feet, when we reach the point where the river emerges from the gorge, we are still six thousand six hundred and fifty feet above the level of the sea, having descended but eight hundred and forty feet. Yet, at this highest point of the section which can be counted as arable, we are five hundred and thirteen feet lower than Fort Sanders, and four hundred and seventy-three feet below Laramie City. At the Three Crossings the height is only six thousand one hundred and thirty-five feet, showing a fall between this point and the head of the valley of five hundred and fifteen feet, or about twelve feet to the mile. At Independence Rock the elevation has decreased to just six thousand feet, giving a fall between this and the last-mentioned point of scarcely five feet to the mile. From here to the point where the river joins the Platte the fall is, probably, some five or six feet to the mile, as it grows a little more rapid as it approaches its debouchure. We may, therefore, estimate the average elevation of the valley at six thousand three hundred feet above the sea level.

For ten or twelve miles below the point where the stream emerges from the mountains there is a very pretty fertile valley, averaging about one mile wide, bordered on the right, and part of its length on the left, with high bluffs. Most of it is covered over with a luxuriant growth of grass, from which a supply is drawn for South Pass City, Atlantic City, &c. Near the lower end of this opening the left bank is flanked by a second level or table, which might be reached by an irrigating ditch, a few miles long, and would give an additional amount of farming land equal to the entire bottom. Below this the hills again close in upon the valley for a few miles, and then separate, leaving a very pretty triangular area, containing some forty or fifty square miles of quite level and fertile land, which can easily be irrigated. Toward the north and northwest the hills slope down so gradually that a considerable area along their lower margins could be reached with water if the river would supply a sufficient amount for this and the bottoms. The stream here is about thirty feet wide and one foot deep, and the fall some ten or twelve feet to the mile. Here, as also in the vicinity of what is known as St. Mary's Station, small colonies would find very good locations; and by combining and digging large primary ditches the land could be irrigated at a moderate expense. The only difficulty, except the exposure to Indian depredations, would be the obtaining of a supply of timber, which at the last point is scarce. Near St. Mary's no difficulty in this respect would be experienced.

From this point the river bends around to the northeast, passing among the hills, and is flanked by alternate bottoms, of small extent. To the south of the river, forming a chord to its circular bend, runs a singular valley, which is some ten or twelve miles wide; and although its surface looks exactly like the plateaus of this section, yet its general appearance is that of the bed of a stream that was very broad and shallow. If the water of the river can be brought upon this level, as much land can be irrigated as the water of the river can supply. But as I had no opportunity of ascertaining the height of this plain or valley above the river level, I cannot say positively that the water can be brought upon it.

Where the road again strikes the river, going east, there is a considerable expanse of arable land; and, although there is very little immediate bottom, the second level is quite broad and of moderate elevation, which might be irrigated by cutting a ditch a few miles in length. Below this, as we come near the "Three Crossings," the granite hills set in and continue to flank the valley as far as Independence Rock. Near the west end of this irregular range, for some seven or eight miles, the river breaks through it, and is closely walled in by lofty bluffs, with here and there a little level plat containing a few hundred acres of fertile soil. Around the south side of these bluffs runs an open plain, several miles in width, which probably might be reached by a ditch some twelve or fifteen miles in length. There is near the remains of the old stage station (Three Crossings*) a very remarkable evidence of the effect of the wind: an immense deposit of sand in a bend of the granite hill, piled up against the bluff like a huge snow-drift.

After passing through the gorge here the river enters a broad and beautiful valley, the upper portion of which is thickly covered with chenopodiaceous shrubs, the lower part being covered with a tall and thick growth of grass. The soil, though somewhat sandy, is very rich and light, and if irrigated would produce heavy crops of such products as are adapted to the climate. The immediate bottoms are narrow, sometimes entirely absent, but the second level is not more than ten or fifteen feet above the water, and could be reached by a ditch four or five miles long. And I think it probable an area of 80 to 100 square

* These stations—St. Mary's, Three Crossings, and Sweetwater—have been abandoned for some years, but I use them to give names to the localities, as they are yet retained on some maps.

miles could be brought under cultivation here, and as timber could be obtained from the neighboring hills this would be a good point for a settlement. The Union Pacific Railroad is not more than sixty miles distant from this place.

In the vicinity of Hayden's Peaks,* the granite hills on one side and bluffs on the other press close to the margin of the river for a short distance, then receding from each other in a circular sweep again come close together a few miles beyond, inclosing a beautiful circular area containing some twenty or twenty-five square miles of fertile bottom land, which, as it is but slightly elevated above the water, can be irrigated without difficulty.

Passing the gate-like opening of the little park just described, we enter upon a broad valley, which continues without interruption to the "Devil's Gate," about four miles above Independence Rock. A good part of this valley is covered with "grease-wood" and sage, but the soil is very fertile and will produce good crops. Muddy Creek, which comes in here from the south, has a tolerably broad margin of level land, but I doubt about it affording water for irrigation. The breadth of land here is probably equal to the supply of water. Around Independence Rock and for several miles above and below it are fine bottoms which can be irrigated. Between the river and Horse Creek there is a broad delta, which has an average elevation of twenty or thirty feet above the bed of the river, but less than that above the level of the creek. This plateau, and, in fact, a considerable area east of Horse Creek, could be reached by irrigating ditches, but the ditch from the river would require two short aqueducts at the Devil's Gate. The soil of this plain is strongly impregnated in some places with alkali, otherwise it is rich in the elements of fertility. At present it is covered with "grease-wood" and sage, except in the little areas which are frosted over with alkaline incrustations; but this is no longer a terror to the agriculturist, who has learned how to manage it, if he only has an abundance of water and sufficient drainage. Along the ridge lying north of this plain, around the head-waters of Horse Creek and over the summit in the vicinity of Willow Springs, are some excellent grazing lands. The country along the Platte, from the mouth of Sweetwater to Poison Spring Creek, is broken and mountainous, and the river for part of the way runs through deep gorges and falls in this distance over four hundred feet, the fall from Independence Rock to Red Buttes being about five hundred and forty feet.

The length of the Sweetwater Valley, from its commencement above St. Mary's Station to the Platte, is about ninety miles, and the average width of the land which can be brought under cultivation may be safely estimated at six miles. This would give a cultivable area of five hundred and forty square miles, or about three hundred and fifty thousand acres for this section, besides a few small areas on the upper portions of the Sweetwater that may possibly be brought under cultivation and made to yield some of the hardier crops.

I am aware that the dreary and desolate appearance of some parts of

* Immediately north of Sweetwater River, about latitude 42° 28′, west longitude 107° 24′, the granite range bends around toward the west. On this semicircular portion there are three peaks; the one to the west shoots up in a sharp point, the one to the east is cleft by a deep notch, while the middle one is round and dome-like. As these prominent points had previous to our arrival received no names, the members of the party named them "Hayden's Peaks," in honor of the leader of the expedition. On the map compiled by Colonel William E. Merrill, under order of General Sherman, entitled "Map of Utah and Colorado," and published in 1869, they are included under the general name, "Granite Ridges."

this section which I have described as susceptible of cultivation will have a tendency to make some of the many who have traveled over this old emigrant route mistrust my judgment. I may be mistaken in reference to the amount of land which can be brought under cultivation, for this is only an estimate made up without measurement, (except the direct distances as shown by the odometer,*) from estimates of the various parts, but if the supply of water does not fall short, I think this is not too large. And I have learned that the dreary look a covering of sage and grease-wood gives to the landscape is not to be taken as any evidence of the sterility of the soil. I am also pretty well satisfied that the climate here will prove more favorable to agriculture than that of Laramie Plains, and that the cereals (except corn) and the ordinary vegetables can be raised without any difficulty. I know of no experiments having been made in this section to show what can be grown here, therefore have to judge from the character of the soil, elevation, latitude, surroundings, and the temperature so far as I could learn from those who had passed through it.

As a grazing region it is inferior to the Laramie Valley, yet the river bottoms and mountain slopes (the granite hills excepted) afford very good grass. Timber is also scarce from the vicinity of St. Mary's Station to the mouth. Here and there are groves of willow, and in the upper valleys a few cotton-wood trees, but those which formerly grew along this route, and which are mentioned by Frémont, have nearly all been destroyed by the emigrants and others who have since traveled the road. It is possible that when the stream is full timber may be floated down from the mountains near South Pass.

THE EASTERN SECTION.

This section, the principal part of which lies east of the Black Hills, constitutes the remaining portion of the district under consideration. It consists of the valleys of the North Platte and its tributaries, from the Red Buttes to the mouth of Horse Creek, on the eastern boundary of the Territory. It also includes the valleys of Crow Creek, Larren's Fork, and Lodge Pole to the boundary line, and the intervening plains, containing about nine thousand square miles, of which I estimate one-sixth, or nearly one million acres, can be irrigated and rendered tillable. I was at first disposed to set down the amount of land in this section, susceptible of cultivation, at considerably less than these figures, but when I examined the barometric record showing the fall of the Platte I felt assured my first estimate was too small. The elevation, as might be inferred from the situation, varies considerably in the different parts, the northwestern and southwestern angles presenting the highest points, and the northeast the lowest. In order to give an idea of the topography of the country, I herewith note the elevation of the principal points bearing upon its facilities for irrigation on a large scale. Beginning at Red Buttes and following the Platte, which runs near the northeast border of the section, the elevation above the sea level is as follows: Red Buttes, 5,528 feet; five miles below the Old Bridge, 5,252 feet; river bottom near Fort Fetterman, about 4,970 feet;† Fort Laramie, accord-to Frémont, 4,470 feet, and as given by Stansbury, 4,519 feet; mouth of

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* I was careful to obtain the distances each day from Mr. Beaman, that my comparisons might be made on the ground.

† The barometric observation was taken on the La Prele, about two miles above Fort Fetterman, where the elevation is just 5,012 feet; I have deducted 42 feet as the probable fall to the river bottom.

Horse Creek, 4,395 feet. From which it appears that the entire fall from Red Buttes to Horse Creek is 1,133 feet, or an average of about seven feet to the mile. The fall between the intermediate points are as follows: From Red Buttes to the Bridge, eighteen feet to the mile; from the Bridge to Fort Fetterman, a little over seven feet to the mile; from there to Horse Creek, about the same.

These figures develope a fact of the utmost importance in calculating the agricultural capacity of this section. A fall of over one thousand feet in less than one hundred and fifty miles, with the volume of water found in this part of the river, will give the means of irrigating an immense amount of land. But in regard to this I will speak more fully when I come to the more minute description of this part of the section.

The elevation of Laramie bottom, at the mouth of Chugwater, is about four thousand five hundred feet above the level of the sea.* The Chugwater Valley, where the stage road to Fort Laramie strikes it, has an elevation of five thousand four hundred and sixty feet; Cheyenne, six thousand and forty feet.

Poison Spring Creek is a small stream coming down from the northwest, and entering the North Platte at Red Buttes. It runs through a very pretty valley, averaging about one mile wide, flanked on the west by a broad plain, which gradually ascends as it recedes from the stream. On the east the hills rise rapidly to a sharp ridge running parallel with the creek. It has been stated that the water of this stream is poisonous, but I noticed some of our animals drinking from it as we crossed it, and I think one of the men also filled a canteen with the water for drinking on the road. No bad effects followed. Some two or three species of plants were also growing luxuriantly in the stream. The amount of water at the time we passed it (August) was small, but sufficient to irrigate the immediate bottoms. The entire valley was covered with a rank growth of grass.

Near the Red Buttes, in the bend of the North Platte, is a beautiful bottom of perhaps one thousand two hundred or one thousand five hundred acres of fertile soil. On one side of the river there is a thick grove of cottonwood, willow, &c., but on the other (north) the timber has been destroyed by emigrants and others who have camped at this point.

Immediately below this the river enters a gorge or cañon some eight or ten miles long, where, as a matter of course, no cultivable land worthy of note is to be found. The slopes toward the river, except for a very short distance, are not so precipitous as to present any serious obstacle to the cutting of a canal around them, if it should be found necessary to tap the river this high up. On the south side a canal could reach as far up as the mouth of the cañon above Red Buttes, but on the north side the depression at Poison Spring Creek would present a serious obstacle if commenced higher up than the upper end of the cañon. As the fall between Red Buttes and the Old Bridge is nearly or quite four hundred

*The barometric readings taken by Mr. Beaman on the Laramie bottom, some two or three miles above the mouth of the Chugwater, give four thousand five hundred and thirteen feet as the elevation at that point. Four very uniform readings were obtained, the weather being clear and cool. The distance from this point to Fort Laramie is about twenty-one or twenty-two miles. Mr. Frémont gives the elevation of Fort Laramie as four thousand four hundred and seventy feet, while Stansbury, who, it seems, camped on the same ground, or very near it, makes it four thousand five hundred and nineteen feet. As we did not visit Fort Laramie, I have no means of ascertaining where the error lies. As Mr. Beaman's instrument did not admit of accurate readings nearer than one tenth, an error of fifty or sixty feet might have occurred in his calculations. As the Laramie runs pretty rapidly, the fall between Chugwater and the fort cannot be less than one hundred feet.

feet, it would be sufficient to carry the water on the table lands which spread out from here eastward. On the north side a short tunnel might be necessary, but below this point, so far as I observed, there would be no other difficulty than an occasional lengthy flexure round the head of a dry ravine, and perhaps here and there a short aqueduct. On the south side I think there would be less difficulty. I make no pretensions here to engineering accuracy, as I only had time to take hasty glances at the country as we passed along in our somewhat rapid march. A short distance below the Old Bridge I made an approximate estimate of the volume of water in the river. I found that a cross section at the low stage of water of that season (August) was equal to one hundred and sixty by two feet, or three hundred and twenty square feet, running at the rate of three miles per hour, or a discharge of two hundred and sixty-four cubic feet to the second, which, earlier in the season, when most needed for irrigation, must be much greater. With this amount of water, and the considerable fall there is in this part of the river, making ample allowance for errors in the elevation, a vast body of land can be irrigated and brought under cultivation.

It is true that all this land on the north side of the river lies in an Indian reservation, but this renders a knowledge of the fact only the more important; for, in my judgment, if the Indian problem is ever solved without destroying them, it will be by the aid of agriculture.

In order to show that the soil of this region is possessed of the elements of fertility, I quote the following remarks from General Frémont's report, which will doubtless be corroborated by the report of the United States geologist for the present year:

The nature of the soil may be inferred from its geological formation. The limestone at the eastern limit of this section (between Fort Laramie and Red Buttes) is succeeded by limestone without fossils, a great variety of sandstone, consisting principally of red sandstone and fine conglomerate. The red sandstone is argillaceous, with compact gypsum or alabaster, very beautiful. The other sandstones are gray, yellow, and ferruginous, sometimes very coarse. The apparent sterility of the country must therefore be sought in other causes than the nature of the soil. The face of the country cannot with propriety be called hilly. It is a succession of long ridges made by the numerous streams which come down from the neighboring mountain range. [By this he alludes to the south side.] The ridges have an undulating surface, with some such appearance as the ocean in an ordinary breeze.

I did not have an opportunity of seeing the North Platte bottoms but a part of the distance between the ruins of Fort Casper and the boundary line. I will therefore limit myself to a description of these portions, from which a pretty correct idea of the whole may be formed, as they are said to be quite uniform throughout.

In the vicinity of Fort Casper, on the south side of the river, there is a broad level bottom, some four or five miles in width, mostly covered with a rank growth of grass mixed with tall weeds, showing the soil to be quite fertile and that it contains a moderate proportion of vegetable mold. Below this a second level sets in, which is raised but a few feet above the lowest. This is one entire sage plain, and spreads out to some eight or nine miles in width. Before reaching Muddy Creek, the low, rounded hills approach the river for a few miles, narrowing the bottom to a mere strip. At Muddy it again expands to six or eight miles, and is covered in part by a thick growth of greasewood. The creek, although containing a considerable volume of water, is confined to a very narrow, ditch-like channel, cut in the fine-grained soil, which here has a marly appearance.

The opposite side of the river for most of this distance is bordered by low bluffs, which seem to be the escarpments of a plateau from a hundred to a hundred and fifty feet high. At some points these recede from the river, leaving a narrow belt of bottom land. For some distance above Fort Fetterman there is a broad valley, partly bottom land and partly the second level, all of which could be easily irrigated, and would afford a fine farming region.

I think we may safely estimate the average width of the immediate valley of the river, from Fort Casper, or the Old Bridge, to the territorial line, at four miles. This alone would give a cultivable area of six hundred square miles. Add to this the additional amount which can be brought into use by the canals heretofore proposed, and the estimate I have given for this section will not appear too large.

West of Fort Fetterman, Deer and Box Elder Creeks flow into the Platte from the south, each affording a narrow belt of irrigable land, and fields of excellent pasturage, the principal supply of hay for the fort being cut from the valley of Deer Creek. The La Prele, which connects with the Platte near the fort, is bordered chiefly by high hills and bluffs, its bottoms being narrow and irregular and the supply of water small.

There is one thing which will probably have a tendency to retard the settlement of this part of the Platte Valley; that is the wind. Our attention was first called to this while crossing a broad valley a few miles south of Fetterman, where a strong and constant wind swept down upon us from the west. While camping on the La Prele this was of daily occurrence; and from Fetterman to Poison Spring Creek we felt its effects each day, except when sheltered behind some bluff or ridge. While crossing the river near old Fort Casper, and for a few miles along the north bank, where we were directly opposite the mouth of the gorge, the wind was so strong that we were compelled to tie our hats upon our heads, yet the day was clear and sunny.

Frémont in his report says this place is celebrated for winds, of which the prevailing ones are west; which corresponds with our experience, with this exception, that when south of Fetterman they came from the northwest. Stansbury, while in the vicinity of Box Elder Creek, speaks of a "brsk wind from the northwest," adding that the morning was bright and cool. And he also states that after he had passed through the gap to the vicinity of Poison Spring Creek, "the wind rose from the southwest and blew almost a hurricane the whole day, tearing up the sand and gravel, and dashing it into our faces, as we rode, with such violence as to cause sensible pain." And the cause of this I think is apparent. Here the mountain range is completely severed, and an open gap exists between the western and eastern plains. Through this the cooler surface atmosphere of the higher mountain plains rushes down to fill the space left by the warmer ascending air of the broad eastern plains. It is true this kind of movement is going on along the entire mountain range, but it is in a quiet manner, while here the entire volume from a broad expanse is pressed through a narrow channel, and as a necessary consequence the current is strong. Having passed through the gap it expands upon the open space to the east, sending currents along the valleys north and south.

Between Fort Fetterman and Laramie River a number of streams rising in the Black Hills run east and empty into the Platte, the most important of which are the La Bonté, Elkhorn, Horseshoe and Bitter Cottonwood. The La Bonté drains a very pretty and fertile valley which is of moderate width, and is covered at points with groves of cottonwood, willow, &c. This valley is pretty well shielded, for most of its length, by high hills which border it on each side, and presents a good point for a small farming settlement. Horseshoe and Elkhorn Creeks are flanked by narrow bottoms, but as the supply of water is not constant throughout their course they cannot be depended upon for irrigating purposes unless the water is brought down by ditches which begin near the mountains.

The bottoms of Bitter Cottonwood are only of moderate width, but for most of its length these are bordered by second levels of considerable width which are quite low. The water of this creek is probably sufficient, in the first part of the summer, to irrigate the entire lands in reach, but late in the season it would be deficient.

The soil in this valley is not so good as that of the La Bonté.

The valleys of the Laramie and its principal tributary, Chugwater, present the most desirable points for agricultural purposes in the section. In fact I consider the short valley of the Laramie River, from the mountains to the Platte, one of the choice spots of the entire district. The elevation being about one thousand five hundred feet less than Cheyenne, and two thousand six hundred feet lower than Laramie City; and shielded from the winds by the mountains on the west, and the high bluffs and hills on the north and south, it possesses a climate several degrees warmer than most of the section, and is not so liable to be visited by those untimely frosts and snows which often do so much injury to crops in this mountain district. The extent of the bottom is not very great, the entire area probably not exceeding seventy-five or eighty square miles, yet the fall of the river and volume of water are sufficient to irrigate much of the bordering table lands. The supply of timber is ample, the mountain heights affording an abundance of pine and fir for lumber, and the groves of the bottoms cottonwood for fuel, &c.

Frémont bears testimony to the moderate climate, saying, "The winter here is remarkably mild for the latitude; but rainy weather is frequent, and the place is celebrated for winds, of which the prevailing one is west. An east wind in summer, and a south wind in winter, are said to be always accompanied with rain." What he says in regard to the place being celebrated for winds is certainly true, as a general rule, and while this may apply directly to the eastern end of this valley and the table lands, I think the bottom lands are generally screened by the hills and bluffs.

Stansbury, although unfavorably impressed with this region generally, remarks in regard to the lower part of this valley, "That he has no doubt that, with the aid of irrigation, the bottom land of Laramie Creek may be made to produce abundant crops;" and that "hay is cut about eight miles up the stream in quantity sufficient to supply the garrison."

The Chugwater runs northeast for some thirty-five or forty miles along the base of the Black Hills, watering a beautiful valley, which averages about two miles wide. This valley is bordered on each side by high bluffs, which wall it in for the greater part of its length. The bottoms are very fertile and easily irrigated, and the supply of water is probably sufficient for this purpose, although it appears to sink at some points and then rise again, but if drawn off by irrigating ditches this would be prevented and the supply would be constant.

Horse Creek and its affluents furnish a considerable amount of valley land and level bottoms, but, with the exception of that found along the main branch, which rises in the mountains, little of it can be brought into use by the usual system of irrigating, as the supply of water is not constant. Reservoirs along the little affluents would be the means of bringing a large body of land under culture. The same remarks will apply to Larren's Fork, which, as it is not a mountain stream, dries up in the latter part of the season.

Lodge Pole Creek is an isolated stream rising near Cheyenne Pass and flowing with a moderate fall eastward through a narrow valley, bordered each side by broad, rounded ridges. The amount of bottom land is limited, but as much, perhaps, as the water in the stream will supply. It is probable that by commencing a canal near the mountain a much larger and more constant supply could be obtained; and the upper lands and broad ridges can easily be reached if water can be obtained.

Crow Creek rises in the Black Hills west of Cheyenne, and, running east for a short distance beyond this city, bends south and passes into Colorado. Although the valley is narrow and the stream small, its situation renders it important, and efforts are now in progress which will probably develop the entire capability of the stream. If the supply of water was sufficient the entire plains around the city could be irrigated and the land made to produce useful crops.

I have been informed that the Union Pacific Railroad Company intend shortly to take steps to irrigate some of their lands in the southeast part of Wyoming by canals, but as they neglected to furnish any information on this point, I can state nothing positively in regard to it.

I am of the opinion that the rain-fall is on the increase in the immediate vicinity of this city, and that as the land is irrigated and brought under cultivation, this increase will become more rapid. And the importance of the subject and locality will be sufficient excuse for my giving my reasons for this opinion.

While remaining in camp at Fort D. A. Russell for several days in 1869, and also in 1870, I noticed that the rains would generally commence several miles to the west, and moving north for some distance would wheel around eastward and then bear down upon us from the north. I think nine out of every ten followed this course during the time I noticed them, which was in the months of July and August. As Cheyenne Pass, which lies north of the fort a few miles, affords a depression through which the air from the west rushes down, we may conclude that a large eddy in the surface currents exists here. I know nothing in regard to the course of the winter rains and storms. If I am right, then the influx of population into the southern rim of this eddy will, by increasing the evaporating surface of the water, increase the amount of rain in this circuit. These remarks, as a matter of course, only apply to the limited rains of the spring and summer.

This section has a milder climate than any other portion of the district, yet its parts differ considerably in temperature, corresponding somewhat to the elevation and freedom from prevailing winds. As the population is confined almost exclusively to Cheyenne and vicinity, we have no means of comparing records of the seasons.

All the agricultural products which can be grown in the other sections of the district can be raised here; and in addition to these it is very probable that corn can be raised in the lower valleys.

Fine grazing fields are to be found throughout the section, in the valleys and along the slopes of the mountains, and even where there are no running streams wells may be dug and water found at moderate depths, which can easily be raised by wind-mills in sufficient quantity to supply stock and possibly assist in irrigation.

Timber in abundance can be obtained along the mountains and on some of the streams from Chugwater north. I believe some saw-mills have already been erected on the upper portions of the last-named stream.

The soil and face of the country is very similar to the South Platte district until we pass Laramie River going north, when it begins to assume the wave-like appearance noticed by Frémont.

Some experiments have been made in farming and gardening around Cheyenne, at Fort Fetterman and other points, which are, perhaps, the coldest portions of the section, yet the results, so far as I can learn, have been quite favorable.

THE WIND RIVER DISTRICT.

As I did not have an opportunity of visiting this district, I can only give such information respecting it as I derived from others. The principal facts in regard to its extent and productions were obtained from Major Baldwin, who is thoroughly acquainted with it, and who has a farm there under cultivation. I also saw specimens of its productions in quantity, which were brought to South Pass City for sale, which verified the statements made to me respecting its climate and fertility. It is drained by the Wind (or Big Horn*) River and its tributaries, and is situated between the Wind River Mountains on the west and Big Horn Mountains on the east. From the borders of Little Popoagie to the Big Horn Cañon, its length is about one hundred and seventy-five miles, and the average width of the country drained being about one hundred miles, giving an area of seventeen thousand five hundred square miles. It is supposed that one-twelfth of it, or about one thousand four hundred square miles, can be irrigated and cultivated, but as I was unable to obtain any estimate of its subdivisions, except that of the principal valley, I cannot say that this is approximately correct, but I do not think it exaggerated if the reports as to the supply of water be true.

Wind River rises in Wind River Mountains, on the west side of the district, and, flowing a little south of east for some sixty or seventy miles, bends abruptly north, which is its general course from this point until it passes out of the Territory. The length of its valley is estimated at two hundred miles, and its width from two to fifteen, but it is interrupted at some points, especially at the irregular range of hills or mountains that crosses the district from east to west near the middle of its length.

The following tributaries flow into the main stream on the north and west side: The North Fork, Owl Creek, Gray Bull, and Stinking Water Creeks. On the south and west side are the following affluents: South Fork, Buffalo Bull Creek, Big Popoagie River, Beaver Creek, and No-Wood River. Little Wind River and Little Popoagie Creeks are tributaries of Big Popoagie. All of these streams are bordered by more or less arable land, which is generally quite fertile and can be irrigated, as the supply of water is ample. I understand the Indian agency here intends cutting a canal and drawing the water from Wind River above the bend, which, it is estimated, will irrigate several thousand acres. All of these streams, except No-Wood River, are skirted by heavy growths of cottonwood and willow. Wheat, oats, and barley can be raised with ease, the climate being sufficiently mild and the season of sufficient length for them to mature, but it is rather severe for corn. Potatoes and cabbages grow finely and of pretty good size, but the turnips I saw, if a fair sample, did not indicate a favorable locality for their production. Somewhat to my surprise, the beans raised here, of which I examined several bushels in the green pods, were very large, plump, and well filled, which would indicate a freedom from late frosts

*This stream is called Wind River until it passes through the first range of mountains, north of which it has received the name of Big Horn River.

I did not expect to find here. But since that time I have learned some facts which go to show that there are some valleys and localities even north of this, especially on the west side of the range, where the climate is comparatively mild, and where not only the hardier cereals, but corn can be raised, and will produce a moderately good crop.

I do not know what the elevation of this valley is, but am inclined to believe that it is lower than that of the Sweetwater. Major Baldwin thinks that it will not average more than five thousand feet above the level of the sea.

I believe the greater part of this district is embraced in an Indian reservation; but, as I have heretofore remarked, this only makes a knowledge of its agricultural capacity the more important.

THE WESTERN DIVISION.

A full consideration of the territory on the western slope of the great divide, lying opposite to that in the eastern division, would include, not only the Salt Lake basin, but also the vast district drained by the Rio Colorado of the West and its numerous tributaries. But this I am unable to do, especially in regard to the latter; for while my observations and information extended over the greater part of the Great Salt Lake basin, they were limited, in the Rio Colorado district, to a part of the Green River country, the valley of the Rio Virgin, and the head-waters of the San Juan and Flax Rivers. The last two I have embraced in my report on New Mexico, and the valley of the Rio Virgin I will include in a description of the Salt Lake district, leaving only the Green River section to be described separately. This, I am aware, breaks in upon my plan of making each separate water system a district, but as I am unable to carry it out in this case, I thought it best to throw the different parts of the Territories together as much as possible consistent with the general plan.

This division is a part of the great inter-alpine trough lying between the Rocky Mountain and Sierra Nevada ranges, which terminates north in the plains of the Columbia, and is lost in the south in the broad plateaus of Arizona and Mexico. Its situation, so far from the immediate Pacific slope and Mississippi Valley, with immense rugged ranges of mountains on each side, and yet on the line of travel between the Atlantic and Pacific shores, renders a knowledge of its agricultural capacity of great importance. And a more complete investigation on this point by the Government would not be money spent in vain.

The lowest level of the area under consideration is reached in the Salt Lake Valley, which is about four thousand three hundred feet above the sea, while various arable points in each district are found as high as seven thousand feet.

THE GREEN RIVER DISTRICT.

I regret my inability to describe this district in full, not only because without it my work is incomplete, but more particularly because I think there is here a large body of irrigable land, which is unoccupied. It is probable that the portion of the area, drained by Green River and its tributaries, which lies within Wyoming Territory, amounts to some fifteen thousand or sixteen thousand square miles. The southeastern part consists principally of broad barren sage plains, with but little water, and is, as a general thing, of but little value, unless it can be redeemed by means of artesian wells. The southern part is composed chiefly of boulder ridges and plateaus, with washed and bluffy escarpments, in consequence of which the term "bad lands" is sometimes applied to it. This section is partially supplied with streams bordered with narrow arable strips, which can be irrigated, and, notwithstanding their barren appearance, are really quite fertile. The southwest corner is broken and mountainous and contains very little land that can be cultivated, but includes some fine grazing fields. The northern triangular section, lying between the Wind River and Wahsatch Mountains, contains the greater part of the arable land in the district, and is divided into three distinct parts or sub-sections, as follows: the Green River Valley, the Big Sandy Valley, and the broad, somewhat elevated plains lying between them.

Green River, rising in the Wind River Mountains near Frémont's Peak, runs in a southerly direction for about one hundred and twenty miles to the 42d parallel, where it turns southeast, and is joined by Big Sandy, where it crosses the 110th meridian. It continues the same course, after receiving the waters of the Big Sandy, to the crossing of the Union Pacific Railroad, where it again turns south and passes out of the Territory. Between its source and the 42d parallel it is joined by a number of small affluents that flow down from the mountains on the west, the more important of which are, Lead Horse, Marshy, White Clay, Butternut, Piney, La Barge, Fontenelle, and State Creeks.

Although I have not had an opportunity of a full examination of this part of the section, yet I am satisfied there must be a large amount of arable land that can be irrigated by the waters of these creeks. And this opinion is strengthened by observing the volume of water in the river above its junction with the Big Sandy, for where we crossed it in September, (the time of year when its waters are low,) it was about one hundred and twenty feet wide, with an average depth of fifteen inches, and running very swiftly. There is but one stream of any importance—the New Fork—that comes in from the east, but this is the longest tributary north of the bend.

I do not know what the fall of the river is, but it must be considerable, as its current is rapid and its bottom, where I saw it, covered with clean round pebbles. I suppose it cannot be less than eight or ten feet to the mile, which is sufficient to reach the surface of the broad plateau that spreads out east of it. If I am correct in my conclusions, it will be possible to irrigate a body of land equal to the entire capacity of the stream, and we may therefore safely estimate the amount of land in this section which can can be brought under cultivation at eight or nine hundred square miles. It is true this estimate is based on slender data, but I think it cannot be too large, for the Green River bottoms alone will make one-fourth of this amount, while the larger irrigable area is on the second level or table lands, which vary from fifteen to fifty feet in height, above the waters of the stream and spread out to great width. The broad tract that spreads out between this river and Big Sandy is level and sandy, presenting a barren and desolate appearance, on which account it is sometimes called "The Colorado Desert." It is covered with a low growth of *Artemisia*, and a close examination of the soil shows that it possesses the elements of fertility, and only needs the addition of water to make it productive. Although the supply of water from Green River is not sufficient to irrigate all this extensive tract it will furnish a broad belt of it. The Big Sandy rises in the Wind River range a few miles to the northwest of South Pass, and runs south until it is joined by the Little Sandy—its principal tributary—when, bending southwest, it continues this course until it joins Green River. The upper portion passes almost its entire length through a level sage plain, averaging about twenty-five or thirty feet higher than the surface of the creek. The immediate bottoms are generally narrow, and often wanting on one side. The fall of the creek here is sufficient to carry the water on the plains, but the supply is not sufficient to irrigate a belt more than a mile or two in width. The country bordering the upper portion of Little Sandy is somewhat broken and hilly, particularly on the east side, but it enters the plains before it is joined by Pacific Creek, and is flanked throughout by all the level land its waters can irrigate.

The Big Sandy, from the point where it is joined by the little Sandy to its mouth, runs through a narrow valley, generally flanked on one side by tolerably high bluffs, which are the margins of the elevated plains that here rise from seventy-five to one hundred feet above the creek. The average width of the immediate bottoms is, perhaps, half a mile, but the upper level can be reached with canals a few miles long, and the breadth of cultivable land increased to the full extent of the supply of water. The elevation of the little Sandy bottom, just above its junction with Pacific Creek, is six thousand four hundred and fifty feet above the sea, while that of Big Sandy bottom near Big Timbers—twenty-five miles by the road from the former—is five thousand eight hundred and eighteen feet. This shows that between these points there is a fall of over twenty feet to the mile. Ten miles further down, where it empties into Green River, the altitude is five thousand five hundred and six feet above the sea level, showing a fall of nearly thirty feet to the mile, which is sufficient to reach the highest plateaus which border the valley.

Although I traveled over this sub section, and noted carefully everything observable bearing upon its agricultural capacity, yet I am unable to form any very reliable estimate of the area of its irrigable lands. This difficulty arises from a want of information concerning the volume of water these streams send down during the irrigating season. If, as is probably the case, they are much larger at that season than when we crossed them, then the estimate of the tillable lands must be much larger than if judged by the water at the time of our visit. Assuming the larger volume, I would place the estimate at about one hundred and twenty square miles in this sub-section.

The average elevation of this entire section is between five thousand five hundred and six thousand five hundred feet above the sea level, which is lower than that of the Laramie Plains, but the climate is not so temperate as that of the Salt Lake basin. Wheat, oats, barley, and such roots and vegetables as are mentioned as growing at Laramie City, can be raised here.

The north part of the Green River Valley may have some good grazing fields, but neither the lower part of this valley nor that of the Sandy afford any very extensive or valuable areas suitable for pasturage.

There is some cottonwood along the Green River and the lower part of Big Sandy, but as a general thing this entire region is destitute of timber, none being found nearer than the mountains.

The remainder of my report on this district relates only to such detached portions as were visited by the expedition.

Black's Fork, to the point where it is joined by Ham's Fork, is bordered by a bottom of moderate width, which will afford space for a number of farms, and a grazing area of considerable extent. At the time of our visit to this place, a drove of one thousand cattle was resting and feeding here, preparatory to their departure west. This stream, to its junction with Green River, is flanked by narrow bottoms, which are fertile and well grassed, as a general thing, and which can easily be irrigated. As there is a tolerably good supply of water during the growing season, it is probable a portion of the uplands, where level, can be irrigated, thus increasing the tillable area. The higher plateau between this stream and Henry's Fork is beyond the reach of irrigation, but between this and the streams around it runs a lower level, varying in breadth from a few rods to ten or twelve miles, and generally about fifteen or twenty feet above the immediate creek bottoms. This level, which is mostly covered with a thick growth of *artemisia*, can be irrigated as far as the supply of water will go. The broad expanse around Church Butte can be reached by a canal some eight or ten miles in length, but the supply of water in Black's Fork is hardly sufficient to justify the expense. A canal might probably be cut from Green River, commencing some eighteen or twenty miles above the railroad, which would not only irrigate the broad level portions of the plains lying west of the river and south of Ham's Fork, but if a suitable place for crossing Black's Fork Valley with an aqueduct can be found, might also supply the first level south of the latter stream.

Around Fort Bridger, on the head-waters of Black's Fork and its tributaries, Smith's Fork and Cottonwood Creek, are some fine farming lands, and on Smith's Fork a number of farms are already in cultivation, producing fine crops of wheat, oats, barley, potatoes, &c. The tillable area in this neighborhood amounts to several thousand acres.

A proposition has been made to run a branch railroad from some point on the Union Pacific Railroad near Carter Station, up Smith's Fork, to the Uintah Mountains, in order to reach the abundant supply of pine timber to be found there.

The altitude of Fort Bridger is about seven thousand feet above the sea level.

Concerning the country east of Smith's Fork I quote from the journal of Dr. Turnbull, as during the passage of the expedition over this section I was absent examining the lands of Utah:

"From Fort Bridger to Henry's Fork, with the exception of the valley of Smith's Fork, the country has a sterile appearance and is without means of irrigation, being generally covered with a scattering and stunted growth of *artemisia*.

"Henry's Fork traverses a beautiful valley, something like thirty miles long and from two to five miles wide, can be easily irrigated, and will produce heavy crops of cereals and the hardy roots and vegetables. At present it is covered with a luxuriant growth of grass, from which not only a supply for the military post is obtained, but also for shipment to other points. During the time of our passage through this region, some twenty-five hundred head of Texas cattle were resting and feeding at Brown's Hole.

"The valley of Green River, between Black's Fork and Bear River, is generally narrow, varying in width from a few rods to three or four miles, but as we approach the mouth of Vermillion Creek it widens out into a broad, bay-like valley about twelve miles long and seven or eight in width, which is one broad meadow. On the east side of the river, between Currant and Red Creeks, there is a broad sage plain of moderate elevation, which could be watered from the river by means of canals a few miles long, and, although having a barren look, would doubtless produce good crops.

"From Bitter Creek east, until we reach Muddy or Washakie Creek, a tributary to Bear River, the country is desolate and uninviting, and the water generally bad, being impregnated with alkaline matter. At the latter plenty of good grass is to be obtained, but the irrigable and tillable area is limited."

From the data obtained by the expedition while in this section, I am led to the conclusion that a thorough investigation of the northeast part of Utah and northwest part of Colorado would reveal the fact that there is a large area of land there which can be cultivated, not in extensive bodies, but in long narrow valleys and belts. But it is probable the reports of others, who have been making some examinations of this mountainous region, may supply that which we have to omit for want of information.

Timber is abundant along the slopes of the Uintah Mountains, and some of the valleys are tolerably well supplied with cottonwood.

SALT LAKE DISTRICT.

This district, which lies partly in Utah and partly in Nevada, is a vast elliptical basin about three hundred and fifty miles in length from north to south, and varying from fifty to three hundred miles in width, being on an average about one hundred and eighty or one hundred and ninety miles wide, and containing an area of some sixty-five thousand square miles. As there is a large portion of this territory which is but little known, and which has never been examined with a view of ascertaining its agricultural capacity, it is very difficult to give even an approximate estimate of the cultivable lands within its bounds. Omitting what may hereafter be discovered to be cultivable in the western section, I think we may safely place the estimate at three thousand square miles, or about two million acres.

An irregular range of hills or mountains starting from the west side of Salt Lake runs south a little west of the 113th meridian to the 38th parallel, when it bends southeast and forms an imperfect junction with the southern extremity of the Wahsatch Mountains. By this range the basin is divided into two unequal parts, that on the east, which contains nearly all the known arable land, being much smaller than the western section.

This latter portion consists chiefly of broad, flat, sandy plains, often destitute of vegetation, and in many places covered with saline incrustations, showing plainly that the lake formerly extended over a much larger area in this direction than at present.

As this western section, so far as known, contains but very little arable land—this being limited to the extreme southeast border—and as the entire basin consists of minor basins with distinct water systems, I shall not attempt to consider the district by sections, but will describe it by the minor basins and valleys, so far as I have visited them and obtained reliable information concerning them. Leaving out of the list the broad northwestern plains, the following are the more important minor basins: the Salt Lake Basin, Rush Valley, Sevier River Basin, and Beaver River Basin.

SALT LAKE BASIN.

This basin embraces the territory immediately around the lake, and that drained by the numerous streams that flow into it, of which the principal ones are Bear, Weber, and Jordan Rivers, the last including as its tributaries the streams that discharge their waters into Utah Lake.

This basin is nearly two hundred miles in length, and covers over one-fourth of the entire district; and within its bounds are contained the choice lands and chief population of Utah.

Beginning at the north end of the lake, and moving east and then south, I will describe the country, so far as my observation and information extend, by valleys, in the order in which they come.

I did not visit either Hansee Spring Valley or Blue Spring Valley, which lie north of the promontory; nor did I succeed in obtaining any very definite information concerning the agricultural capacity of either; but from all I could learn I am satisfied they contain very little arable land. The former is not supplied with streams that will furnish water for irrigation, and the principal stream in the latter is very strongly impregnated with saline matter. The southern portions of these valleys have a barren appearance, and are but sparsely covered with vegetation; the soil is also saturated with salt or alkali. Farther north there are probably some better portions and some small areas susceptible of cultivation, and grass may also be found near the mountains.

The Malade Valley, which extends north into Idaho, is drained by the Malade River, and is a very pretty, fertile section; and, including the shore of Bear River Bay, is about forty miles long, with an average width of five miles. It contains about one hundred and fifty square miles of land which may be irrigated, and in the northern part are some fine fields of grass. Although the Malade River is narrow, it sends down a considerable volume of water, sufficient, I think, to irrigate all the level land of the valley as far south as the "gate," or cañon, through which Bear River emerges. From this point water can be drawn from the latter stream to irrigate the south end of the valley. Although a portion of the land near the bay may be unfit for agricultural purposes, yet several thousand acres can be brought under cultivation in the vicinity of Corinne, where it would doubtless prove quite profitable.

The Cache Valley, the next one to the east, is an expansion of the otherwise ribbon-like valley of Bear River, and extends north and south from the divide between Muddy and Box Elder into the southern border of Idaho. Its length from Paradise to the mountains above Franklin is about fifty miles, varying in width from six to sixteen and averaging as much as twelve miles. About one-half of its area, or three hundred square miles, can be irrigated and rendered suitable for cultivation. Not only can the bottoms be irrigated, but the benches and uplands between Paradise and Franklin may be reached by digging ditches a few miles in length; for, in addition to the river, there are numerous little streams running down into the valley from the Wahsatch Mountains on the east, as follows: Muddy, Blacksmith's Fork, High Fork, Gros Bois Creek, and Logan's Fork, and Rush Creek from the west, all of which afford water.

This is probably the finest grazing section in the entire basin, and situated as it is near the junction of three railroads, must become a favorite pasture ground for stock-raisers and stock-traders. Occasionally, feeding may be required for a short time in the winter, on account of the snow, but this seldom extends over three or four weeks during the season. This is also one of the best wheat-growing valleys in the district, being second to none but the San Pete. It is colder than the valley of the Jordan, as is also that of the Malade, and therefore not so well adapted to fruit or corn as the sections farther south, yet apples and the hardier fruits can be raised. The attractive features and situation of this valley have drawn a considersble population here, so that already between thirty and thirty-five thousand acres have been irrigated.

Box Elder, and the other little streams that connect with it, are bordered by some excellent lands which can be easily irrigated. A settlement has been made here and some land is under cultivation, but what amount I am unable to say.

Bear River rises in the Uintah Mountains, near the southwest corner of Wyoming, and running north within Utah Territory, but very near the eastern boundary, passes up into Idaho for forty or fifty miles, where, bending suddenly southwest, it enters the Cache Valley. Most of the distance from where the Union Pacific Railroad enters it, to its northern bend, it is flanked by a narrow belt of bottom land, which occasionally, as in the vicinity of Medicine Butte, and near the point where it crosses the boundary line, expands to four or five miles in width, but for the whole length the average width cannot safely be estimated at more than one mile. Its chief value will be as a grazing region when the broader valleys have been taken up, its elevation and mountainous surroundings making it too cold for any but the hardier cereals and vegetables.

The average fall of the river is about twelve feet to the mile, which is sufficient to carry it upon any table lands that may border it which are not more than one hundred to one hundred and fifty feet high.

I am not sufficiently acquainted with the country through which it runs to state what is the probable amount of land that may thus be rendered cultivable. I know there are occasional belts of the second level, but I think these are limited. Around Bear River Lake there is a strip of arable land and some grassy meadows.

Ogden's Hole, which is a little park in the Wahsatch Mountains, drained by Ogden Creek, is about fifteen miles long and seven miles wide.

This beautiful valley is hemmed in on all sides by high mountains, from which flow down little streams of crystal water sufficient to irrigate nearly the entire area. The greater part is covered over by a thick growth of nutritious grass, and affords an excellent grazing field. The remarks made in regard to the climate and products in Bear River Valley will apply here.

Weber River, along which the railroad runs for some distance—from where it emerges from the cañon to where it enters upon Salt Lake Valley proper—passes through a very pretty, and, for the most part, fertile section, which is rapidly filling up with villages and settlements, and is so well known to every one who has traveled along the Union Pacific Railroad, that any description of it would be superfluous.

The arable land in the valley, including the little spots on Echo Creek, may be estimated at one hundred square miles, or sixty-four thousand acres.

I may add that the soil is very fertile, and, although the climate is slightly colder than that of the Salt Lake Valley, apples and some other fruits can be raised without difficulty.

In order to prevent confusion, I have limited the name "Salt Lake Valley" to the strip of level land lying along the eastern shore between the lake and the Wahsatch Mountains. Its length from Salt Lake City to Willard City, in a direct line, is about fifty miles, varying in width from two to fifteen miles, and averaging about ten.

Of this area I estimate three-fifths, or three hundred square miles, as susceptible of cultivation. I am aware that with the present systems of irrigation it would be difficult, if not impossible, to obtain sufficient water to irrigate this extent, but by making reservoirs and bringing upon it all the water that is within reach from the streams north and south, my estimate will not be too large; and, by this means, part of the higher lands south of Weber River may be rendered fit for culture.

The soil, although in many places covered with artemisia, and more or less impregnated with saline matter, is very rich and productive, as the farms already under cultivation show.

The northern and southern portions contain the principal settlements, as there the land is lowest and most easily irrigated.

As the productions of this and the remaining portions of the basin are similar, I will speak of them after I have described the different sections.

The valley of the Jordan extends almost directly north and south from Utah Lake to Great Salt Lake; the lofty peaks of Wahsatch range walling it in on the east, and the Oquirrh Mountains bounding it on the west.

From the lower end of the cañon to its northern extremity, where it spreads out and becomes a part of what I have included in the Salt Lake Valley, is about twenty-six miles, and its average width fully fifteen miles. This gives nearly four hundred square miles as its area, which may appear small to those who have read the glowing descriptions of it. Lieutenant Beckwith gives thirty miles as its length, and twenty as its width; but he counts from Utah Lake and includes the mountain slopes, while I confine my estimate to the valley plains, four-fifths of which can be irrigated; and I also exclude from the calculation that part of the lake shore bordering the river, which I have included in the former section.

The direct length, by Government survey, from the base line which runs near the north side of the city to the southern line of Salt Lake County, which crosses near the cañon, is just twenty-four miles.* The greater part of this beautiful valley can be irrigated, and I estimate its cultivable area at four-fifths, or about three hundred square miles.

Most of the tributaries of the Jordan enter it from the east side, and south of the creek that waters the city the only ones of any importance are Mill, Big Cottonwood, Little Cottonwood, and Willow Creeks. Ditches have recently been made along the eastern border of the valley, drawing the water from Cottonwood Creeks near the mountain and carrying it on the plateau that occupies a considerable area on this side of the river.

This effort has clearly demonstrated the possibility and practicability of irrigating nearly every acre on the east side of the river, north of Willow Creek. Although but little of this plateau or higher level has been tilled, yet the primary canals and a number of the smaller ditches are already made, and when I passed through the valley in September last were filled with running water.

In the vicinity of Willow Creek there is a small area of slightly rolling land, which probably cannot be irrigated from any of the streams, not because of its elevation, but because this creek does not furnish sufficient water. If it is possible to establish reservoirs along the base of the mountain there will be no necessity for even this remaining idle.

An extensive canal is now in course of construction for the purpose of irrigating the great body of land on the west side of the river. Starting within the cañon, and but a few feet below the level of Utah Lake, the intention is to carry the water from the Jordan along the base of the Oquirrh Mountains, at as high a level as possible. This will furnish

* The table of distances given in Stansbury's Report, p. 294, makes the distance from the State House to the summit of the hill at the cañon twenty-five miles, which is the correct road measure.

water enough to irrigate the larger portion of the lands on this side; but the fall is not sufficient to reach the higher margins of the sloping plain.

When these works are completed and the fresh water from Utah Lake has permeated the soil for a few years, this valley, seen from some neighboring height, will truly appear as one vast garden.

The soil of the flat lands around the city, when the Mormons first settled it, was so thoroughly saturated with saline matter that for several years there were considerable areas upon which they could get no crops to grow. But at length by experience they learned that by sowing it in herd-grass and irrigating it freely it could be rendered suitable for the culture of other crops. And Mr. R. L. Campbell, who was for some years secretary, and is now, I believe, president of the Agricultural and Manufacturing Society, informs me that lands which were heretofore rejected on this account are now being rapidly occupied for farms.

It is impossible to give the exact number of acres that have been irrigated in this valley, as no returns, so far as I could ascertain, have been made since 1867. Omitting from the estimate the lands that may be reached by the Jordan Canal, which is not completed, I suppose the number at present amounts at least to twenty thousand or twenty-five thousand acres.

Perhaps, before passing to the Utah basin, it would be best to include the Tooele and Lone Rock Valleys, as they properly belong to this group of arable tracts.

The Tooele Valley is about sixteen miles long and ten miles wide, and is probably the most fertile spot in the Territory. The small streams that run through it afford sufficient water to irrigate the greater part of its area, and therefore I estimate its agricultural lands at one hundred and sixty square miles, or the full extent of the valley surface. The soil appears to be peculiarly adapted to the growth of the cereals, it being no uncommon thing to cut from sixty to seventy bushels of oats from an acre, and last year one field of ninety acres averaged sixty bushels to the acre. It is already pretty well settled up, having one woolen manufactory and five grist-mills, and some fourteen or fifteen thousand acres irrigated.

Lone Rock or Spring Valley, which lies at the southwest corner of Salt Lake, does not appear to have attracted much attention, and is not so well known as the others in this region, probably, on account of its locality. It is about twenty miles long and from eight to ten miles wide, and, with the exception of its northern end, is well grassed over and affords excellent grazing fields. A small area can be irrigated and brought under cultivation around the southwest margin, but the central portion is watered principally by springs, which render the surface marshy in places. Ditching through the marshy parts would probably draw off sufficient water to leave the ground firm and suitable for grazing and, perhaps, for culture. The northern portion, as it approaches the lake, assumes a more barren appearance, and in some places is frosted over with saline incrustations, while the southern end is much like Tintic Valley.

UTAH LAKE VALLEY.

Passing southward over the ridge at the upper end of the Jordan Valley, we enter the Utah Lake Basin. The principal portion of the arable lands of this basin or valley stretch along the eastern shore of the lake, extending back from its margin to the foot of the mountains, which here descend abruptly to the plains. The length of this semicircular belt, from the exit of the Jordan to Santaguin, is about fifty miles, with an average width of six. This entire area of three hundred square miles can be irrigated, the numerous streams that rush down from the mountain cañons affording sufficient water to irrigate not only the lower bottoms, but also the broad elevated plateau that extends from Battle Creek to Provo River.* For a long time this plateau was supposed to be beyond the reach of any of the streams in the vicinity, and was consigned to inutility, but a little energy has recently shown that this was a mistake. A canal, commencing some distance up Provo Cañon, has been constructed along the steep mountain slopes, and now brings the water from Provo River to the highest point of this elevated plain, and when I passed through here the secondary ditches were filled with water, spreading here and there large pools over the dry plains. Although I saw but one field in cultivation, farms were being marked off and preparations made for cultivating the soil. And I believe that this once rejected plat will prove the best wheat-growing tract in the valley of Utah Lake, and that ere long it will be dotted over with farm-houses and fields of golden grain.

The following is a list of the streams that run down from the mountain and cross this shore-strip, given in the order in which they come, beginning at the north end of the lake. Dry Creek, American Fork, Battle Creek, Provo River, Spring Creek, Hobble Creek, Spanish Fork, and Petenete Creek; Summit Creek, which crosses the road south of the lake, is a tributary of the Petenete. These streams are bordered by no valleys or bottoms within the mountains, for, with the exception of Provo River, they do not reach beyond the first range, but rushing down its slope enter suddenly upon the plain and sweep across it to the lake.

The soil is generally very fertile, that along the margin of the lake having a large proportion of vegetable mold mixed with it; that near the mountain and on the plateau is intermingled with small boulders, but not to such a degree as to injure it. From Battle Creek north, and from Provo River south, it is pretty well settled and most of the choice bottom lands occupied, but there is a broad strip along the lake margin not cultivated but used as meadow land to graze the cattle belonging to the citizens of the little villages located on the creeks. Including Tintic and Cedar Valleys there are at least twenty-five thousand acres of irrigated land in Utah County, and even this estimate may fall considerably below the true figures, for if the canal cut from the Provo is of sufficient capacity to water the whole surface of the plateau, this alone would amount to over twenty thousand acres, and would increase my estimate to thirty-five thousand, as I include but ten thousand in the first figures.

Tintic Valley, which lies southwest of Utah Lake, is a narrow, baylike indentation in the range of hills or low mountains that sweeps around the west side of the basin. It is about twenty-five miles long north and south, and four or five miles wide, and is watered principally by springs. As there are very few streams from which water can be drawn to irrigate the soil, a small portion only of the land can be brought under culture, but as a grazing section it probably stands next to the Cache Valley. The grass grows luxuriantly and is kept fresh and nutritious by the water from the numerous springs, and the comparatively mild climate prevents the necessity of winter feeding or shelter, as sometimes required in the north part of the Territory.

* This stream was formerly called the Timpanogas, and this is the name generally found on the maps and in public documents.

Cedar Valley lies west of the lake, behind the range of hills that here rises up near the shore, and is about thirty miles long from north to south, and averages ten miles in width, and contains perhaps one hundred and fifty square miles of land that can be cultivated. It is watered by two small streams that run in from the west and northwest, and which afford sufficient water to irrigate the northern and western portions, especially around Crittenden and Cedar City. The land is good and productive. The valley is partially settled, and there are already two saw-mills and one flouring-mill in operation here. I did not have an opportunity of visiting this locality, but obtained my information from citizens of Provo, who are well acquainted with it. I neglected to inquire about its water drainage, and am somewhat in doubt respecting it. If there is any outlet for it to the lake, I failed to see it, and I am satisfied there is none to the Jordan, therefore I presume it is a separate basin, but as it may belong to the Utah basin, I have considered it in connection with that system. It has a greater elevation than the Utah Valley, but how much I do not know.

Moving southward from Santaguin, we enter the Juab Valley, which extends from this point to the divide between Utah and Sevier basins, a short distance below Nephi. It is about fifty miles long and six miles wide, and contains one hundred square miles of land that can be irrigated, principally along Salt and Clover Creeks. The most of the remainder is well grassed over, and affords good pasture lands for sheep and cattle.

Reserving a fuller account of the productions of the Salt Lake, Jordan, and Utah Valleys, until I have completed the description of the district, I will only remark that everything that can be raised in the Middle States can be raised here, and that these sections bear about the same relations to the colder regions of the elevated mountain districts and southern borders of our Territory that the Middle States do to New England and Georgia.

Without detracting anything from the importance of the arable tracts and grazing fields along the railroad line east of this in Wyoming, I may truly call this basin, with all its drawbacks, (for it has some,) an oasis on the great continental highway of trade and travel. Possessing this advantage of situation, surrounded by mountains rich in the precious metals, and having a healthy climate, it must, in the course of a few years, become densely populated. It is important, therefore, that the Government should give all proper encouragement to its development. I make these remarks here, because they are more particularly applicable to the immediate basin of Salt Lake than to the rest of the Territory, being the portion through which the railroad passes.

The general level of the Salt Lake Valley is about four thousand three hundred feet above the sea level, and that of Utah Lake Valley between four thousand five hundred and fifty and four thousand six hundred feet.*

In the mountains east of the Jordan are three little parks or elevated valleys, Parley's Park, Kamas Valley, and Round Prairie, which belong to the basin under consideration. Parley's Park is elevated about two thousand feet above Salt Lake, and is some five or six miles long and from two to three miles wide. It is watered by Cañon Creek, and could be easily irrigated, but on account of its elevation and mountain-

* In the barometric table accompanying Lieutenant Beckwith's Report of Pacific Railroad Survey, vol. ii, part 1, p. 107, there are some errors, probably typographical. For instance, the elevation at Provo is given as 4,362.6, when it certainly is at least two hundred feet more.

ous surroundings, it is too cold for any except the hardier productions. The recent discovery of some mines in the mountains around it, however, may bring it into notice.

Kamas Valley, which is similar to Parley's Park, is about ten miles long and from two to four miles wide, and can also be irrigated. Both are well grassed and afford good grazing fields, but, on account of the difficulty in reaching them, and their small size, will not be of much value in an agricultural point of view.

I know nothing in regard to Round Prairie.

RUSH VALLEY.

This valley appears to be a small isolated basin, having a distinct water system of its own; Rush Lake, which lies in the north part, being the reservoir. It is about forty or fifty miles in length from north to south, and averages fifteen miles in width, a large portion of which can be irrigated, and which I have estimated at three hundred square miles. Clover Creek, which flows into Rush Lake, is a stream of considerable size, and affords sufficient water, not only to irrigate a large extent of land, but also power to drive machinery. The lake is about eight miles long and some three or four miles wide. Some mines recently discovered at the north end of this valley will, if they prove productive, furnish a market for the farm products.

Stockton, at the north end of the lake, is a village of considerable size. The farms in this locality are irrigated from a stream that runs from the mountains near by and empties into the lake.

SEVIER RIVER BASIN.

This comprises the country drained by the Sevier River and its tributaries. This river, rising in the southwest corner of the Territory, runs a little east of north between two ranges of the Wahsatch Mountains for one hundred and fifty or one hundred and sixty miles,. where it breaks through the western ridge and runs southwest for forty or fifty miles more, and empties into Sevier Lake. Its principal tributaries are the San Pete River and Meadow Creek. The former, rising a little south of Mount Nebo, runs southwest through the San Pete Valley and joins the Sevier River near the crossing of the 112th meridian and 39th parallel. The latter commences in the divide south of Rush Valley, and traverses the plains west of the mountains, uniting at the bend. Very little appears to be known in regard to Sevier Lake, at least I have been unable to ascertain anything of importance respecting it or the lower portion of the river. The very irregular form of this basin and uncertainty in regard to its western rim make it impossible for me to give an estimate of its area that will amount to anything more than a mere guess.

The San Pete Valley, which is watered by the San Pete River and numerous small tributaries, counting from Fountain Green to Gunnison, is forty-four miles long and averages fully five miles in width. At least two hundred square miles, or nearly the entire surface area of this beautiful and fertile valley, can be irrigated. The returns of the Agricultural and Manufacturing Society for 1866–'67 give nearly twenty thousand acres as the number then under irrigation; the past three years have increased this fully twenty-five per cent., so that we may safely estimate the number now irrigatedat twenty-five thousand.

This valley, as a wheat-growing section, stands next to Cache, its soil being peculiarly adapted to the production of this cereal. It is also one of the best potato regions in the Territory.

Its altitude averages about five thousand feet above the level of the sea, the elevation at the mouth of San Pete River being four thousand nine hundred and sixty feet.

The Sevier River Valley is a long narrow belt lying between two wings of the Wahsatch range, and extending northwest and northeast one hundred and ten or one hundred and fifteen miles. I know but little respecting the agricultural features of the upper portion of this valley, but presume, judging from what I know of the surrounding regions, that it is well grassed and well watered, so that all spots of arable land to be found there can be irrigated. I think it probable that some timber can be found in this part of the valley, although the lower portions are very naked.

For about fifty or sixty miles above Gunnison it averages some six or seven miles wide, but is wholly without timber, and has a very barren appearance; even the artemisia being scattered and stunted. The river channel is generally a deep, ditch-like cleft in the soil, some six or eight feet below the surface of the plain, its immediate bottoms being very narrow. With the considerable fall in the stream a great portion of the valley can be irrigated, and, notwithstanding the present barren appearance, after a few years' irrigation, will become quite fertile, and produce good crops of wheat, oats, potatoes, &c. There are some settlements in the north part of the valley, and a few thousand acres under cultivation in Sevier and Piute Counties, which embrace this valley. What the number of acres irrigated is I cannot say.

The elevation ranges from five thousand five hundred to four thousand eight hundred feet above the level of the sea, and the volume of water in the river is ample for all purposes. From Gunnison to Chicken Creek, a distance of forty miles, the valley of this River averages some three or four miles wide, and is similar in character to that farther south.

Leaving the Sevier, and following the road over the ridge to the southwest, we enter an isolated basin called Round or Lake Valley, which appears to have little or no connection with the water systems of the Sevier basin. This is some ten or twelve miles long and six or seven wide, but for want of water only a limited portion of it can be irrigated and brought under culture. There is probably sufficient to supply a strip of about a mile and a half in width. And there are some small grazing fields here. Passing westward out of this valley we enter upon the margin of the plains, which spread out with a gentle slope to the northwest. The little streams that run down from the mountains and pass off into the plains afford a belt of arable spots along the foot of the range, concerning which I obtained the following particulars from Bishop Miller, of Provo:

Going south from the latter point, after passing for some ten miles over the divide, we reach a little stream where there is a small settlement and a small extent of arable land that can be irrigated, and an area ten or twelve miles long and four or five wide, suitable for grazing sheep or cattle. Passing over a dry level plain for about eight miles farther, we reach Chalk Creek, which affords a valley eight or ten miles long and about two miles wide, the greater part of which can be irrigated. Crossing another dry level of about four miles we reach Meadow Creek,* which has but little bottom land adapted to agriculture, and not sufficient water to irrigate more than a few hundred acres. But it

* This is a different stream from the Meadow Creek heretofore mentioned as coming down from near Rush Valley.

is probable that a ditch could be brought round from Chalk Creek, by which a considerable area of the upper level might be rendered tillable.*

Corn Creek, which is about five miles farther south, is flanked by a moderately broad area of flat land, which can be irrigated to the full extent of the supply of water. Cove Creek Valley, ten or twelve miles farther on, furnishes but little farming land, but contains some good grazing fields, and is already occupied, to a considerable extent, for this purpose. Five or six miles south of this is another small stream (probably Pine Creek,) where sufficient land for a few farms might be irrigated.

Passing over a divide of some nine or ten miles we reach Indian Creek, a tributary of Beaver River, which brings us into another basin. Although there are two stage routes through this section, there seems to be but little known respecting its water system; in fact, the very existence of Preuss Lake appears to be a matter of doubt, and future investigation may show that this is but a part of Sevier River Basin. Considering it as a separate system, it consists of Bear River and its tributaries, which rise in the western slope of the range of mountains before mentioned.

There is a considerable area of land on Beaver River that can be irrigated and cultivated, and the probability is that its breadth might be increased by extending canals on the upper levels below the mountain or ridge that crosses here. Passing over Beaver Mountain we reach Yellow Creek, where there is a fertile belt about ten miles long and six or seven miles wide, reaching from the Creek about two miles south of Parawan. Here, and at Beaver River, are some settlements and some land already under cultivation. Between Parawan and Cedar City there are a few arable spots of small extent, which are already partly occupied. Cedar City is situated on Cole Creek, a stream about the size of the American Fork, which will irrigate some four or five thousand acres. Shirt's Creek, which runs by Kanara, is flanked by a considerable bottom, but the stream does not afford water sufficient to irrigate but a part of it. West of this some twenty or twenty-five miles, on another branch of Beaver River, are the celebrated Vegas de Santa Clara, noted as a resting place after the fatigues of the desert march from the West. By following these various streams, as they move northwest toward some common reservoir, it is probable a number of irrigable spots may be found.

Crossing over the divide, which here sweeps round in a semicircular form from a southwest to a northwest direction, we enter the valley of the Rio Virgin, a part of the vast territory drained by the Rio Colorado of the West. This stream, although sending down a considerable volume of water, is wide and rapid and consequently shallow. It runs through a country having a very barren appearance, here and there cutting through rocky cliffs and lava ridges, with occasional broad stretches of sandy land covered with a very scanty growth of vegetation. But, notwithstanding the unpromising appearance of this section, there are several settlements here, some of which (as Washington and St. George) number several thousand souls.

There are some arable spots which are very productive, and in fact

*All the maps I have seen, including even the very accurate map of Colorado and Utah, prepared by order of General Sherman, have an error in this section. They have a number of small streams represented as rising in the plains west of the mountains opposite Sevier River and running through the range to the River, to do which it would be necessary for the water to run up hill. They rise in the range, and, running northwest into the plain, are lost in the sands, as all who have traveled along the stage route here know, and as Frémont shows in his report.

wherever water can be obtained, and the land irrigated, the soil becomes very fertile. The arable areas around Toqueville, and from there up the river, are very limited, but about Washington and St. George they are more extensive, and the entire Santa Clara Valley, for fifteen or twenty miles in length and two or three miles in width, can be cultivated. And one or two canals are being cut along the Rio Virgin which will add considerably to the cultivable area. This section, on account of its semi-tropical climate, is considered by the Mormons of great importance, for they look to this for their supply of cotton, raisins, oranges, and other products, which cannot be grown in the Salt Lake Valley.

In regard to the vast region east of the Wahsatch range, and south of the Uintah Mountains belonging to the Rio Colorado district, I know but very little.

Strawberry Creek, a tributary of Uintah River, runs through a very pretty valley for twenty or twenty-five miles, which averages seven or eight miles in width. The greater portion of this area can be irrigated, and would produce good crops of such things as are adapted to the climate, which, on account of elevation and the proximity of mountains, is cold.

The Uintah Valley is more extensive, and has in it some very good land, a large portion of which may be rendered suitable for culture by irrigation, for which purpose the supply of water is ample.

CLIMATE AND PRODUCTIONS.

Within the Territory of Utah every grade of climate, from the cold regions of the snowy Sierras to the semi-tropical region of the southern plains, is to be found, but the central portion, where the greater part of the cultivable land is situated, has a mild climate, which, as before remarked, corresponds very nearly with that of the Middle States. As we go north and northeast, ascending the mountain valleys, the climate increases rapidly in severity, and the growing seasons become shorter. As a general thing the annual fall of snow in the valleys is small, seldom more than a few inches in depth, and it remains on the ground but few hours, or days at farthest. In the vicinity of the higher mountains there are occasional frosts that injure the crops.

Wheat, oats, potatoes, and fruit are the principal productions, which not only grow readily and yield abundant crops, but of the very best quality, the soil being naturally adapted to their culture. Something over one million bushels of wheat was raised in the Territory in 1866, but what the ratio of increase has been since that time I am unable to say, but it has not been in proportion to the breadth of land sown, as the grasshoppers have been very destructive for the past three years. Not only have they injured the growing wheat, oats, &c., but, where the ground has been replanted in something else, they have, in some instances, cut it down for the sixth time in one season. The average yield per acre, of favorable seasons, is from twenty-two to twenty-six bushels, but in certain localities it will reach much higher figures.

Cache, San Pete, and Utah Counties are the principal wheat-growing sections, not because they produce more to the acre, but because more acres have been cultivated in this cereal in these counties than any others. I did not have an opportunity of examining carefully the different specimens of wheat grown in the Territory, but, judging by the bread made from it, I presume it to be superior in some respects. It is probable that the flavor and lightness of the bread are partly due to the alkali with which the soil of the valleys is more or less impregnated.

As is generally the case throughout the Rocky Mountain regions, oats grow luxuriantly, the average yield per acre in the Territory being from thirty to forty bushels. It is no uncommon occurrence for the farmer here to cut an average crop of sixty bushels to the acre. Although a large amount of corn is raised, and crops of forty and fifty bushels to the acre produced, yet this cannot be considered a good corn-growing country. And I may add that, so far as my observations have extended, I have seen no really good corn section west of the rain-moistened portion of the Mississippi Valley. That there are many places where tolerably good crops can be raised, and sufficient to supply local demands, is true, but what I mean is that the corn of these Territories bears no such comparison with the corn of the Mississippi Valley as the wheat does.

Sorghum appears to grow finely, and, as I have heretofore stated in regard to beets, I am inclined to the belief that in this dry soil, consisting principally of silicates, and containing alkali, the production of saccharine matter will be greater than in soil having a large proportion of vegetable mold. And in this connection I may remark that the plums grown here are the sweetest I ever tasted. The same variety raised in California, although sweeter than those raised in the States east, are inferior in this respect to those raised at Salt Lake City. But in regard to pears the case is somewhat reversed as compared with California, but not as compared with those of the States east of the mountains. The same thing is traceable in apples but not in peaches.

Such fruits as apples, peaches, plums, pears, currants, gooseberries, grapes, &c., can be raised in Salt Lake basin and south with ease, but apples and peaches, especially the latter, will be the chief horticultural product. The average yield of peaches to the acre, as shown by the returns, is over three hundred bushels. Last year a gentleman in Provo City gathered three hundred bushels from the trees on a lot twelve rods long by six rods wide. For the past three years the fruit has been seriously injured by the grasshoppers eating off the leaves of the trees, but the injury was probably less than it would have been in a section depending on rain to supply the requisite moisture.

As a grape-growing region this Territory cannot compete with California or even with Southern New Mexico, yet very fine grapes can be raised, and the Rio Virgin section can produce a quality equal to any part of the latter, but the area is limited.

The potatoes are as fine in quality as any I have ever met with; they also grow large, and yield heavy crops.

I noticed a number of fields of lucerne, which is used to feed the cattle of the villages when the pasturage in the vicinity proves insufficient.

Very few of the valleys, except those in the mountains, furnish any timber of importance, but, as a general thing, a supply can be obtained from the neighboring ranges, chiefly pine and fir.

PASTORAL LANDS AND STOCK-RAISING.

It is apparent to every one who has paid any attention to the supply of beef-cattle for the principal markets of our country, that this must come from the grazing fields of the West. Having recently traveled by different routes over the States between the Atlantic shore and Missouri River, I have been astonished to find so few beef-cattle upon the meadows. No doubt the census returns will show heavy figures, yet these are not made up from herds fed for beef, but mostly from the cattle and oxen in use upon the farms. The lands of the States are becoming too valuable to afford the room required for grazing cattle at a price that will compete with the plains of the West and Southwest.

It is therefore a fact conceded that the great bulk of our beef-cattle must be raised upon the grazing fields of the States and Territories west of the Mississippi.

As this report would be incomplete without some remarks upon this subject, and as experience in the Territories is requisite to an accurate knowledge of it, I give the following remarks taken principally from the article of Dr. Latham of Laramie, and published in the Omaha Herald, prefacing them with some judicious remarks from the pen of Mr. Byers in the Rocky Mountain News:

After the mining interest, which must always take rank as the first productive industry in the mountain territories of the West, stock-raising will doubtless continue next in importance. The peculiarities of climate and soil adapt the grass-covered country west of the ninety-eighth degree of longitude especially to the growth and highest perfection of horses, cattle, and sheep. The earliest civilized explorers found the plains densely populated with buffalo, elk, deer, and antelope, their numbers exceeding computation. Great nations of Indians subsisted almost entirely by the fruits of the chase, but with the rude weapons used were incapable of diminishing their numbers. With the advent of the white man and the introduction of fire-arms, and to supply the demands of commerce, these wild cattle have been slaughtered by the million, until their range, once six hundred miles wide from east to west, and extending more than two thousand miles north and south, over which they moved in solid columns, darkening the plains, has been diminished to an irregular belt, a hundred and fifty miles wide, in which only scattering herds can be found, and they seldom numbering ten thousand animals. There is no reason why domestic cattle may not take their place. The climate, soil, and vegetation, are as well adapted to the tame as to the wild. The latter lived and thrived the year round all the way up to latitude fifty degrees north. Twenty years' experience proves that the former do equally well upon the same range, and with the same lack of care. Time, the settlement of the country, the growing wants of agriculture, the encroachment of tilled fields, will gradually narrow the range, as did semi-civilization that of the buffalo; first from the Mississippi Valley westward, where that process is already seen, and then from the Rocky Mountains toward the east; but as yet the range is practically unlimited, and for many years to come there will be room to fatten beeves to feed the world.

This great pasture land covers Western Texas, Indian Territory, Kansas, Nebraska, and Dakota, Eastern New Mexico, Colorado, Wyoming, and Montana, and extends far into British America. The southerly and southeasterly portions produce the largest growth of grass, but it lacks the nutritious qualities of that covering the higher and drier lands farther north and west. Rank-growing and bottom-land grasses contain mostly water; they remain green until killed by frost, when their substance flows back to the root, or is destroyed by the action of the elements. The dwarf grass of the higher plains makes but a small growth, but makes that very quickly in the early spring, and then, as the rains diminish and the summer heat increases, it dies and cures into hay where it stands; the seed even, in which it is very prolific, remains upon the stalk, and, though very minute, is exceedingly nutritious.

In so far as the relative advantages of different portions of this wide region may be thought by many to preponderate over one another, we do not appreciate them at all, but would as soon risk a herd in the valley of the Upper Missouri, the Yellowstone, or the Saskatchewan, as along the Arkansas, the Canadian, or Red River. If any difference, the grass is better north than south. One year the winter may be more severe in the extreme north; the next it may be equally so in the south, and the third it may be most inclement midway between the two extremes; or, what is more common, the severe storms and heavy snows may follow irregular streaks across the country at various points. There are local causes and effects to be considered, such as permanently affect certain localities favorably or the contrary. For instance, nearer the western border of the plains there is less high wind, because the lofty mountain ranges form a shelter or wind-breaker. Of local advantages, detached ranges of mountains, hills or broken land, timber, brush, and deep ravines or stream-beds are the most important, in furnishing shelter, and, as a general thing, better and always more varied pasture ground.

There is never rain upon the middle and northern plains during the winter months. When snow comes it is always dry, and never freezes to stock. The reverse is the case in the Northern and Middle States, where winter storms often begin with rain, which is followed by snow, and conclude with piercing wind and exceeding cold. Stock-men can readily appreciate the effect of such weather upon stock exposed to its influence.

The soil of the plains is very much the same everywhere. To a casual observer it looks sterile and unpromising, but when turned by the plow or spade is found very fertile. Near the mountains it is filled with coarse rock particles, and under the action of the elements these become disproportionately prominent on the surface. Receding from the mountains, it becomes gradually finer, until gravel and bits of broken stone are no longer seen. Being made up from the wash and wearing away of the mountains, alkaline earths enter largely into its composition, supplying inexhaustible quantities of those properties which the eastern farmer can secure only by the application of plaster, lime, and like manures. These make the rich, nutritious grasses upon which cattle thrive so remarkably and to the constant wonder of new-comers, who cannot reconcile the idea of such comparatively bare and barren-looking plains with the fat cattle that roam over them.

Besides the plains there is a vast extent of pasture lands in the mountains. Wherever there is soil enough to support vegetation grass is found in abundance, to a line far above the limit of timber growth, and almost to the crest of the snowy range. These high pastures, however, are suitable only for summer and autumn range; but in portions of the great parks and large valleys, most parts of which lie below eight thousand feet altitude above the sea, cattle, horses, and sheep live and thrive the year round. The cost of raising a steer to the age of five years, when he is at a prime age for market, is believed to be about seven dollars and a half, or one dollar and a half per year. A number of estimates given us by stock-men, running through several years, place the average at about that figure. That contemplates a herd of four hundred or more. Smaller lots of cattle will generally cost relatively more. The items of expense are herding, branding, and salt—nothing for feed.

The following extracts from an article by Dr. H. Latham, in the Omaha Daily Herald of June 5, 1870, give a description of the grazing lands in the North Platte district:

The distance from the mouth of the North Platte, where it joins the South Platte on the Union Pacific Railroad, to its sources in the great Sierra Madre, whose lofty sides form the North Park, in which this stream takes its rise, is more than eight hundred miles. Its extreme southern tributaries head in the gorges of the mountains one hundred miles south of the railroad, and receive their water from the melting snows of these snow-capped ranges. Its extreme western tributaties rise in the Wahsatch and Wind River ranges, sharing the honor of conveying the crystal snow-waters from the continental divide with the Columbia and Colorado of the Pacific. Its northern tributaries start oceanward from the Big Horn Mountains, three hundred miles north of the starting point of its southern sources.

It drains a country larger than all New England and New York together. East of the Alleghany Mountains there is no river comparable to this clear, swift mountain stream in its length or in the extent of country it drains.

The valleys of the North Platte.—The main valley of the North Platte, two hundred miles from its mouth to where it debouches through the Black Hills out on to the great plains, is an average of ten miles wide. Nearly all this area, two thousand square miles, is covered with a dense growth of grass, yielding thousands of tons of hay. The bluffs bordering these intervals are rounded and grass-grown, gradually smoothing out into great grassy plains extending north and south as far as the eye can see.

Its tributaries.—The tributaries on the north side of the Platte are Blue Water, Coldwater, Hill Creek, Raw Hide, Muddy Willow, Shawnee, Slate, and Sweetwater. On the south they are Ash, Pumpkin, Larrons, Dry Horse, Cherry, Chugwater, Sybellie, Big Laramie, Little Laramie, Carter, Cottonwood, Horse Shoe, Elk Horn, Rio a la Prelo, Boisiee, Deer Creek, Medicine Bow, Rock Creek, Douglass, and North, South, and Middle Forks of the main Platte.

These streams, with their smaller feeders, intersect in all directions a great pastural land, interspersing it with rich, fertile valleys, and draining at least forty million acres, affording water for countless herds. Most of the banks of these streams are bordered with timber. Cattle have been wintered on these streams north of Cheyenne, along the base of the Black Hills, around Fort Laramie, for twenty-five years.

Capacity for stock-raising.—Of this country Alexander Majors says, in a letter to the writer of this article: "The favorite wintering grounds of my herders for the past twenty years has been from the Caché a la Poudre on the south to Fort Fetterman on the north, embracing all the country along the eastern base of the Black Hills." It was of this country that Mr. Seth E. Ward spoke when he says: "I am satisfied that no country in the same latitude, or even far south of it, is comparable to it as a grazing and stock-raising country. Cattle and stock generally are healthy, and require no feeding the year round, the rich 'bunch' and 'gramma' grasses of the plains and mountains keeping them ordinarily fat enough for beef during the entire winter."

All this region east of the Black Hills is at an elevation less than five thousand feet.

The climate.—The climate, as reported from Fort Laramie for a period of twenty years, is 50° Fahrenheit. The mean temperature for the spring months is 47°, for the summer months 72°, for autumn 0°, for winter 31°.

The annual rain-fall is about eighteen inches, distributed as follows: Spring, 8.69 inches; summer, 5.70 inches; autumn, 3.69 inches. The snow-fall is eighteen inches. It is of this region that Colonel C. H. Alden, post surgeon Fort D. A. Russell, speaks, when he says: "The largest snow-fall so far, in one month, has been 3 97-1000 inches. The snow in this vicinity rapidly disappears after falling, and it is very rare that there is a sufficient quantity so that it remains long enough to give sleighing."

All this country of the North Platte, east of the Black Hills, is within easy distance of the railroad at Cheyenne, Pine Bluffs, Sidney, and Julesburg. An abundance of timber can be had in the Black Hills for fencing and building purposes for all ranch and stock men in any of these valleys.

Extent and resources of the North Platte Basin.—There is in this North Platte Basin, east of the Black Hills divide, at least eight million acres of pasturage, with the finest and most lasting streams, and good shelter in the bluffs and cañons. As I have said before, we can only judge of the extent and resources of such a single region by comparison. Ohio has six million sheep, yielding eighteen million pounds of wool, bringing her farmers an aggregate of four and one-half million dollars. This eight million acres of pasture would at least feed eight million sheep, yielding twenty-four million pounds of wool, and at the same price as Ohio wool, six million dollars. Now, that money, instead of going to build up ranches, stock farms, storehouses, wooden mills, and all the components of a great and thrifty settlement, is sent by our wool-growers and woollen manufacturers to Buenos Ayres, to Africa and Australia, to enrich other people and other lands, while our wool-growing resources remain undeveloped.

The great Laramie Plains.—As you follow the North Platte up through the Black Hill Cañon you come out on to the great Laramie Plains, which lie between the Black Hills on the east and the Snowy Range on the west. These plains are ninety miles north and south and sixty miles east and west. They are watered by the Big and Little Laramie Rivers, Deer Creek, Rock Creek, Medicine Bow River, Cooper Creek, and other tributuries of the North Platte. It is on the extreme northern portion of these plains, in the valley of Deer Creek, that General Reynolds wintered during the winter of 1860, and of which he remarks, on pages seventy-four and seventy-five of his "Explorations of the Yellowstone," as follows:

General Reynolds's Report.—Throughout the whole season's march the subsistence of our animals had been obtained by grazing after we had reached our camp in the afternoon, and for an hour or two between the dawn of day and our time of starting. The consequence was, that when we reached our winter quarters there were but few animals in the train that were in a condition to have continued the march without a generous grain diet. Poorer and more broken-down creatures it would be difficult to find. In the spring they were in as fine condition for commencing another season's work as could be desired. A greater change in their appearance could not have been produced, even if they had been grain-fed and stable-housed all winter. Only one was lost, the furious storm of December coming on before it had gained sufficient strength to endure it. The fact that seventy exhausted animals, turned out to winter on the plains the first of November, came out in the spring in the best condition and with the loss of but one of their number, is the most forcible commentary I can make on the quality of the grass and the character of the winter.

These plains have been favorite herding grounds of the buffalo away back in the prehistoric age of this country. Their bones lie bleaching in all directions, and their paths, deeply worn, cover the whole plain like a net-work. Their "wallows," where these shaggy lords of animal creation tore deep pits into the surface of the ground, are still to be seen. Elk, antelope, and deer still feed here, and the mountain sheep are found on the mountain sides and in the more secluded valleys of the Sierra Madre range, all proving conclusively that this has afforded winter pasturage from time immemorial. Since 1849 many herds of work oxen, belonging to emigrants, freighters, and ranchmen, have grazed here each winter. It is on these plains, in the Laramie Valley, that Messrs. Creighton and Hutton have their sheep, horses, and cattle, and of which Mr. Edward Creighton, president of the First National Bank of Omaha, says:

[Extract from Edward Creighton's letter.]

"The last four winters I have been raising stock, and have had large herds of cows and calves in the valley of the Laramie. The present winter I have wintered about eight thousand head. They have done exceedingly well. We have lost very few through the whole winter, and those lost were very thin when winter commenced. We had no shelter but the bluffs and hills, and no feed but the wild uncut grass of the country.

"We have had 3,000 sheep the past winter, and they are in the best of order; many are being sold daily for mutton. Like the cattle, they require no food or shelter.

"The high, rolling character of the country, and the dry climate, and short, sweet grass of the numerous hillsides, are extremely favorable to sheep-raising and wool-growing."

There are many other stock-raisers on the plains besides Creighton and Hutton, and there is room for hundreds more. On this plain the settler is near the great forests of pine in the mountains, and in the coal fields of the Rocky Mountains, with several kinds of iron ore, building stone, limestone, and fire-clay. The valleys of Rock Creek, Medicine Bow, and the two Laramies afford large quantities of hay. On these plains alone there is, apparently, no limit to the grazing. The railroad bisects these pasture lands about evenly east and west, giving good facilities for transportation.

North Park.—South of the Laramie Plains is the North Park, one of three great parks of the Rocky Mountains, so fully described by Richardson, Bross, and Bowles. This North Park is formed by the great Snowy Range. It is a valley from six to eight thousand feet high, ninety miles long, and forty miles wide, surrounded by snowy mountains from thirteen to fifteen thousand feet high. These mountain tops and sides are completely covered with dense growths of forests; the lower hillsides and this great valley are covered with grasses. The forests and mountains afford ample shelter from sweeping winds. Here as well as on the Laramie Plains the buffalo grazed in great herds, and here the Ute hunters, from some hiding cañon, dashed down among them on their trained and fleet ponies, shooting their arrows with unerring aim on all sides, and having such glorious sport as kings might court and envy. The Indians are now gone from this valley, and the buffalo nearly so. On the two million acres in this valley not twenty head of cattle graze.

This great park, splendidly watered by the three forks of the Platte, and by a hundred small streams that drain these lofty mountains of their snows and rains—rich in all kinds of nutritious grasses; plentifully supplied with timber; on the tertiary coal fields, with iron, copper, lead, and gold—has not one real settler. There are a few miners, but where there should be flocks and herds of sheep and cattle without number, there is only the wild game—the elk, antelope, and deer.

Demonstrated facts.—The season of 1870 has been a memorable one in the stock business on the Plains. It commenced in doubt, but closes with unlimited confidence in the complete practicability and profits of stock-growing and winter grazing.

Increase of cattle in the West.—The number of cattle in the country west of the Missouri River and east of the Snowy Range is now double, if not four times larger than in 1869. Its present magnitude and future prospects entitle it to a full share of public attention.

Shipments of beef to eastern markets.—Two years ago our beef and cattle were brought from the East. To-day, cattle buyers from Chicago and New York are stopping at every station on our railroads, and buying cattle in all our valleys for eastern consumption. It is safe to predict that 15,000 head of beeves will be shipped from our valleys east the present season. During the past week I have visited some of the great herds on the Plains, and will give your readers an account of them.

The great herds.—The herds of Edward Creighton, Charles Hutton, and Thomas Alsop are grazed on the Big Laramie, which is a tributary of the North Platte. The Laramie Valley is between the Black Hills and the Medicine Bow Range. It is about one hundred miles long and thirty miles wide. It is about midway in this valley, and six miles from the railroad station at Laramie, that these gentlemen have located their stock ranches. They have extensive houses, stables, and corrals. As we leave the station on a beautiful August morning, (which is characterized by the clearest of blue skies and golden sunlight,) you see Mount Agassiz directly in front of you, while Mount Dix and Mount Dodge, with snow-covered tops, are respectively on the right and left.

We follow up the Laramie on a smooth road, which is like rolling the wheels over a floor. We follow the windings of the stream, which is clear as crystal, and pure as the snow from which its waters have just come. We first come to a heard of 4,000 half and three-quarter-breed cows; that is, there are none more than one-half Texan, and many only one-fourth. They are known among cattle dealers as short-horned Texas cattle. There are 3,600 calves in this herd that are from three-eighths to one-half Durham. These cows have been here on the Plains one winter and two summers. All the dry cows are exceedingly fat, and many of the cows, with calves by their sides, are good beef. In this herd are many two-year-olds and yearlings, all fat for the butcher, so far as their condition is concerned. In all this herd there are as many as 9,000 head of cattle—4,000 cows, 3,600 calves, 1,000 two-year-olds, and 500 yearlings.

Their habits.—They range over a country fifteen by twenty miles. The cows and calves run together the year around, and in fact are never separated, but run in families of four, generally, cow, calf, yearling, and two-year-old. They are to be found on the river bottoms in the middle of the day, where they had come about 11 o'clock for water. They return about 4 o'clock in the afternoon to the high grounds, where the rich bunch and nutritious gramma grasses are abundant, and feed till night and lie down on the warm sandy soil till next morning, when they feed till the heat of the day. It is interesting to see the habits of these cattle when unrestrained by herders. They travel back and forth to the water and grazing ground in families and little herds, in single file, like their predecessors of the soil, the buffalo, forming deep paths or trails like them. After having spent three or four hours looking at this herd we pass up the river to the beef herd, which consists of 3,500 fat Texas cattle, in the very highest order at which grass-fed cattle arrive in this world. These cattle have been here one or two seasons, and will weigh upon an average, live weight, 1,300 pounds. They could all be sold to-day for eastern markets at good figures. They have yet three months of good weather to fatten this season, when, with 5,000 more, bought by these enterprising men and on the way here, they will be sold east or slaughtered and sent east in the quarter.

There is, still higher up the stream and nearer the mountains, a stock herd of yearlings and two-year-olds, that occupy our time for an hour or two.

Blooded stock cattle.—Then we cross over to Sand Creek, a small branch of the Laramie, and see the herd of American cattle, which, including Hutton's and Alsop's, numbers 400, mostly cows. They are as fine stock as can be found anywhere. Among this herd are several fine-graded Durham bulls and two thoroughbreds that were bought in Ohio at high prices. These parties are owners of 300 blooded bulls, from which the finest calves are being raised by the cross between them and the graded Texan cow. It is interesting for the stock man to see these calves, which show the Durham so clearly in every instance—another proof of the general law that the stronger and better blooded of the two races will give form and impress to the progeny. This fact is remarkably illustrated in these herds. The second and third crosses, leaving no trace of the Texan blood.

Here on this ranch are 300 brood mares, and some young stock, yearling and two-year-old colts which have been raised here, and have never been fed nor sheltered. They are as large and fine colts as are raised anywhere. These brood mares and colts are herded, but never stabled nor fed winters.

Sheep.—We next proceed to these flocks of sheep, which in all number more than 10,000 head, besides the lambs—of these there are 3,000—making in all 13,000. Some of these are from New Mexico, but the great majority are from Iowa, and are fine Merino sheep. They will average fully five pounds of wool per head. Ample shelters have been provided them in case of storm. Much the larger number of these flocks are ewes. The owners expect to raise 6,000 lambs, and to shear 65,000 pounds of wool next year.

These parties have about five miles of fence, inclosing hay grounds, pastures for riding stock, and other purposes. They have, in all, more than $300,000 invested here, which is a sufficient commentary upon their enterprise, foresight, and courage. They are the great stock princes of the mountains. Of all living men they have done most to solve this question of winter grazing.

We next proceed to the Little Laramie, where Messrs. Mautle & Bath have 400 head of American and half-breed stock; they are at the old stage-road crossing, and have some fine blooded stock. Above them, behind Sheep Mountain, directly under the white top of Mount Dodge, named after General Dodge, on the head of the Little Laramie, is a valley twenty miles long and ten miles wide, divided about equally by the north, middle, and south forks of that stream. These are rapid running streams that never freeze in winter. They have groves of timber on their banks and bottom lands, furnishing shade in summer and shelter in winter. This valley is a pocket in the mountains, having only one point of ingress and no egress but by the same way. Here are 2,900 cattle owned by Lambard & Gray, of New York, Captain Coates, of the Army, and the subscriber. Three men are able to herd them, from the nature of the valley, and it is certainly a cattle paradise. Of this herd, 1,200 are cows, 700 two-year-olds, 300 yearlings, and 700 calves. This stock is short-horned Texan, and a good lot of stock cattle.

Iliff's herds on Crow Creek.—After leaving this herd, we take a three-hours' run on the railroad, which takes us across the Black Hills to Cheyenne, which is the headquarters of J. W. Iliff. His cattle range is down Crow Creek to the Platte, twenty to thirty miles. On this grazing ground he has 6,700 cattle, classed as follows: 3,500 beeves, 2,000 cows, and 1,200 calves. The stock cattle are half-breeds, except yearlings and calves, which he has raised, and which show the Durham cross. The beeves are heavy, fat cattle, ranging in live weight from 1,200 to 1,400 pounds. This whole range down Crow Creek, from Cheyenne to the Platte, affords the best of grasses, and the creek bluffs shelter the stock completely from storms. Mr. Iliff has been the owner of great herds of cattle in the last twelve years, and is firm in the faith that this is the place to raise beef for eastern markets. His cattle have sold in Chicago market from five to six cents per pound, live weight, this season. The whole 3,500 head of beeves will be shipped east this fall. Mr. Iliff is another of those who have demonstrated to the world that we have winter grazing, and in so doing he has made a fortune. Long may such men live to enjoy their fortunes!

On the other side of the Platte, on the Bijou, are the herds of the Patterson Brothers, Reynolds, and John Hitson. These herds number 8,000 head of cattle, 6,000 of them being beef-cattle. The Patterson Brothers are great cattle-raisers and dealers. They own ranches on the Arkansas River, at Bent's Old Fort, and on the Pecos River, below Fort Sumner, in New Mexico. They have handled hundreds of thousands of dollars' worth of cattle in the last five years.

John Hitson is another of the great cattle-raisers and dealers in New Mexico. His herds are numbered by the thousands. His operations are transferred to Colorado now, and so are those of the Patterson Brothers. On Box Elder Creek, which is a branch of the Caché la Poudre, is the ranch and stock range of Mr. Whitcombe, an old settler of Colorado. He has 2,000 stock cattle and some fine blooded bulls. This range and shelter are perfect.

Reed & Wyatt, on the Platte, nearer Denver, have 1,000 head of stock and beef cattle. They are about adding largely to their number.

Farwell Brothers, Greeley, have 200 head of fine American cattle.

Baily, on the south side of the Platte from Greeley, has 400 head of Durham and Devon stock, and 2,000 sheep.

Geary, on the Platte, has 300 head of American cattle.

The Lemons, at Greeley, have 400 head of American stock. In this neighborhood Ashcraft has 400 head of American cattle; Munson has 800 head of cattle and 3,000 sheep. Up the Caché la Poudre are twenty large stock-raisers.

On the Big and Little Thompsons there are some five herds of blooded stock.

After you leave Evans and go south toward Denver, the whole country seems one pasture covered with stock. I traveled over this same ground in 1869, and I am sure there are fully three times as many cattle here now as then. There are hundreds of farmers on the Lone Tree Creek, Caché la Poudre, Big and Little Thompson's Creeks, St. Vrain's, and the many other streams which flow from the mountains to the Platte, who have from one hundred to one thousand head of cattle, a description of whose herds and grazing grounds would take too much space in an article of this kind.

Shipments of cattle West.—Colorado has sold an immense number of cattle this season to Montana, Idaho, Nevada, and Utah. It is safe to say that Montana will receive twenty thousand head of cattle during the season of 1870, four-fifths of which are from Colorado. Many have gone to Utah, Nevada, and Idaho from the same source, and yet, ten years ago, the commercial and stock-growing people of the East did not know that Colorado contained a thousand acres of grass land. To-day they have no idea of the magnitude of her grazing resources.

Leaving Colorado we find some herds along the base of the Black Hills.

North of Cheyenne.—H. Kelly, on the "Chug," has 500 stock cattle. He sold 100 head of American beeves at $70 per head.

Messrs. Ward & Bullock, at Fort Laramie, have 200 head of American cattle.

Adolph Cuny, so long a resident on the North Platte, has a herd of 1,000 stock cattle between Forts Laramie and Fetterman.

Between Cheyenne and Sidney, on the line of the railroad, there are several small herds. At Sidney are the Moore Brothers, who have 12,000 sheep and lambs, and 1,400 cattle; 400 of the latter are American and very fine. The sheep sheared an average of five pounds of wool per head last spring. They are graded merinos, and are in fine condition. There is no disease among them. The Moore Brothers were ranchmen on the South Platte prior to the day of railroads, and are about returning to that stream for grazing. Their place is the valley station of olden fame on the stage road. Above them, on the Platte, at the old "Junction," Mr. Mark Boughton has 2,500 stock cattle. He has as fine a cattle range as there is in the world, not excluding the Pampas of South America nor table lands of Australia.

Farther down the Platte, at O'Fallon's Bluffs, on the north side of the South Platte, Creighton & Parks have 3,500 stock cattle, 400 of which are Durhams. They range twenty miles up and down the Platte. Near them, below, is the herd of Mr. Keith, of North Platte Station, who has about 1,000 head.

Mr. M. H. Brown has 500 head of stock cattle and beeves near the same place.

Across the Platte, in the neighborhood of McPherson, the Bent Brothers have 1,000 head of stock cattle, and will add another 1,000 the present season.

Messrs. Carter & Coe have a large herd near there, which numbers near a thousand.

Mr. Benjamin Gallagher has 1,200 head at the old Gilman ranche, twelve miles from McPherson.

Progress this season.—More real progress has been made in stock matters west of the Missouri this season than in all time before. We have not only added to the numbers of our herds and flocks, but we have given confidence to all our stock-growers and to eastern people in the permanency and profit of grazing in the Trans-Missouri country.

We are now in easy reach of eastern markets. The railways are landing the heaviest cattle in Chicago from the Rocky Mountains at $9 and $10 per head; we can sell thousands and tens of thousands annually to the Pacific slope, and there is still an all-absorbing home demand to stock our thousands of valleys.

The future.—As every country in the West receives a new emigrant, and his plow turns the grass under, that corn and wheat may grow in its stead, the range of the stock-grower is that much contracted and the area of grazing lessened. By reason of the high value of lands for grain-growing purposes the people of the country east of the Mississippi River are already coming to us for beef and mutton. Chicago and New York people are enjoying the juicy steaks from cattle fattened on our nutritious grasses that grow in our valleys and on our mountain sides, close up to the perpetual snows of the Rocky Mountains.

As immigration takes up more and more of the pastures east of us for grain, drovers will be obliged more and more to come to us for beef. Texas, the great hive of cattle, has received three hundred thousand settlers this season. The grazing area of that State has been lessened at least a million acres thereby. Everywhere events point to this Trans-Missouri country as the future dependence of the east for wool, beef, mutton, and horses.

H. LATHAM,
Surgeon Union Pacific Railroad.

TEXAS CATTLE.

The following article from Dr. Latham on the cattle of Texas is very interesting, and may be appropriately inserted here:

Texas is truly the cattle hive of North America. While New York, with her 4,000,000 inhabitants, and her settlements two and a half centuries old, has 748,000 oxen and stock cattle; while Pennsylvania, with more than 3,000,000 people, has 721,000 cattle; while Ohio, with 3,000,000 people, has 749,000 cattle; while Illinois, with 2,800,000 people, has 867,000 cattle; and while Iowa, with 1,200,000 people, has 686,000 cattle, Texas, and forty years of age, and with her 500,000 people, had 2,000,000 head of oxen and other cattle, exclusive of cows, in 1867, as shown by the returns of the county assessors. In 1870, allowing for the difference between the actual number of cattle owned and the number returned for taxation, there must be fully 3,000,000 head of beeves and stock cattle. This is exclusive of cows, which, at the same time, are reported at 600,000 head. In 1870, they must number 800,000, making a grand total of 3,800,000 head of cattle in Texas. One-fourth of these are beeves, one-fourth are cows, and the other two-fourths are yearlings and two-year-olds. There would, therefore, be 950,000 beeves, 950,000 cows, and 1,900,000 young cattle.

There are annually raised and branded 750,000 calves.

These cattle are raised on the great plains of Texas, which contains 152,000,000 acres.

Where they live.—In the vast regions watered by the Rio Grande, Nueces, Gaudalupe, San Antonio, Colorado, Leon, Brazos, Trinity, Sabine, and Red Rivers, these millions of cattle graze upon almost tropical growths of vegetation. They are owned by the ranchmen, who own from 1,000 to 75,000 head each.

Great ranches.—I will describe one or two of these great ranches, which will represent to your readers the large ranches of this cattle hive. On the Santa Catrutos River is the ranch of Colonel Richard King, known as the "Santa Catrutos Ranch." This ranch consists of nineteen Spanish triggeus of land, or 84,132 acres. It is watered plentifully by the Santa Catrutos River and its tributaries. On this ranch are the immense number of 65,000 cattle, 10,000 horses, 7,000 sheep, and 8,000 goats. One thousand saddle-horses and 300 Mexicans are constantly employed in herding, gathering, and driving this stock.

Colonel King brands annually 12,000 calves and sells 10,000 beef cattle yearly, and invests the proceeds in stock cattle, thereby adding to his vast herds, in addition to their natural increase.

O'Connor's ranch, twenty miles below Goliad, on the San Antonio River, is another princely estate. He had 40,000 cattle in 1862, and branded 11,772 calves, and was selling from $75,000 to $80,000 worth of beef-cattle annually. The foundations for this wealth were laid in 1852, when he commenced grazing with 1,500 cattle.

The Robideaux ranch, on the Gulf, between the mouths of the Rio Grande and the Nueces, owned by Mr. Kennedy, contains 142,840 acres. It is a fertile peninsula jutting out into the Gulf, and is fenced on three sides by the waters of the Gulf. The other side is fenced by thirty miles of plank fence; every three miles of this fence has a little ranch for Mexican herders. In this inclosure are 30,000 beef cattle alone, besides the other stock. These three are types of the men in the older cattle-growing region near the Gulf.

The frontier counties are all rich in stock. Jack Young, Throgmorton, Stevens, Callahan, Coleman, Brown, Torrent, Elrath, Comanche, Palo Pinto, Hitt, and Johnson are all great stock counties. These counties comprise the country drained by the thousands of streams that form the Rio Grande, Nueces, Gaudalupe, San Antonio, Colorado, Leon, Brazos, Trinity, Sabine, and Red Rivers, and is one of the best-watered regions in America. The bluffs and table lands bordering and between these streams are covered with "bunch," "buffalo," and mesquit grasses.

The cattle princes of these counties are John Hittson, who has 50,000 cattle; William Hittson, who has 8,000 head; George Beavers, 6,000; Charles Rivers, 10,000; James Brown, 15,000; C. J. Johnson, 8,000; S. E. Jackson, 4,000; Robert Sloan, 12,000, (half Durham stock); Anderson Brothers, 6,000; Coggins & Parks, 20,000; Samuel Vaughn, 6,000; Martin Childers, 10,000; Cunningham, 8,000; Mauskow, 8,000; Lacy & Colman, 12,000; John Chisholm, 30,000.

Jack Hittson.—John Hittson's ranch is in Palo Pinto County, on the Brazos River, where he has 50,000 cattle; he has 300 saddle-horses and 50 herders. He drives about 10,000 head of cattle north annually. Eighteen years ago he was working from daylight till dark in Rust County, Tennessee, a timbered section, felling trees, cutting, rolling, and burning logs, and clearing the land to raise a little corn and wheat. From experience in the forests of Tennessee, he knew that it would take the three score and ten years of a natural life to clear away the trees and wear out the stumps, and not fancying the doom of hard labor for life he sold his land, and with 60 Texan cows and 9 brood mares turned his face toward the setting sun and the grass regions of the Brazos. Less than a score of years have passed and he has 50,000 head of cattle and as many acres of land. Hittson is about forty years old, six feet in height, and broad-shouldered. Has an honest, sunburnt face, with a square, firm-set under jaw, which, as I looked at it, I thought was shut a little firmer, giving him a more determined look than it would otherwise, but for a dozen or two encounters with the fierce and insatiable Comanches, who knew Hittson and his old, long, muzzle-loading rifle well, and now know him with his "Winchester." I have often wondered what they thought when they pounced on him with his new "Winchester," and received ten shots in a minute instead of one in five minutes. They must have thought the old rifle bewitched. At any rate, they will give him a wide berth, unless they can creep upon him as the hunter does upon the buffalo bull he does not dare to face. Mr. Hittson is establishing a ranch on the South Platte, near old Fort Morgan, for use as his general northern headquarters. He will winter 5,000 cattle there this year, and bring 10,000 head there for sale next season.

John Chisholm, on the Concho River, is another of the cattle-raisers and drivers of Northwestern Texas, who carries on the business on a princely scale, and whose experience is much like that of Hittson.

Of the thousands of owners of the 3,800,000 head of cattle in Texas, not one hundred commenced with large means. They have built themselves up from small beginnings, like Hittson and Chisholm.

Markets.—The surplus stock is disposed of by packing, by shipping by steamer to the Gulf States, by driving due north to Abilene, Kansas, and Schuyler, Nebraska, and by the northwestern route to the Pecos River, where the droves divide, some going to Arizona and California by the southern route, the greater number, however, keeping a northern course up the Pecos River to the Arkansas River, crossing at and above Bent's Old Fort, and thence along the eastern base of the mountains, through Colorado and across the Black Hills to the Union Pacific Railroad, and on to the great valleys and markets of Wyoming, Utah, Montana, Idaho, Nevada, and the Pacific States.

Drovers of the northwestern trade.—The parties engaged in this trade are: John Hittson, who has driven 7,000 cattle this season; John Chisholm, 6,000; Frank Turkersly, 1,500; McKidrick, 1,500; Stephen Jones, 2,000; W. A. & W. P. Black, 1,500; James Hart, 1,100; Wilson, 800; J. B. Henderson, 1,600; William Forsythe, 1,500; C. C. Campbell, 3,000; Henry Martin, 1,000; Robert Wyte, 1,500; Samuel Goldston, 1,500; John Anderson, 1,500; James Patterson, 8,000; George F. Reynolds, 5,500; Charles Goodnight, 5,000, and Martin Caven, 1,200. It is estimated by Texas drovers, who have had fine opportunities to judge, that 100,000 cattle have been driven from Texas on this route during the season of 1870. Of this number Montana has taken 20,000, Wyoming 8,000, Utah 8,000, Idaho 11,000, Nevada 7,000, and California 10,000; the other 36,000 have been sold in New Mexico and Colorado—principally in Colorado.

The beeves are selected out before the herds leave the Black Hills west. If fat, they are at once shipped for Chicago and New York; if thin, they are left in the valleys of Colorado, Wyoming, and Nebraska to fatten.

The amount of money handled by bankers along the base of the mountains from Cheyenne to Trinidad is enormous. I have no data from which to calculate the amount, but it cannot be less than $1,250,000. Every settler who comes into any of these mountain Territories, every mine that is opened, every Indian who goes onto reserves and is fed, every soldier who is brought into the country, creates an additional demand for stock cattle and beef. As astounding as the figures may seem, the supply has not been nearly adequate to meet the demand.

Great preparations are being made in Northwestern Texas to gather together herds which in numbers have not been heard of before.

Abilene and Schuyler.—Abilene has been the great market this year. At that place the receipts of cattle have reached the enormous figures of 200,000 head. The shipments for the month of September amounted to 60,000 head, or 3,333 car loads, or 111 car loads per day, for the great corn-fields of Iowa, Missouri, and Illinois. It is anticipated that the shipments will reach 75,000 in October.

This great cattle trade at Abilene, which has assumed such gigantic proportions, was initiated in 1867, and has therefore counted only four seasons. In 1867, 75,000 head of stock were received; in 1868, 125,000; in 1869, 150,000; in 1870, 200,000. In 1869, one bank alone in Kansas City handled $3,000,000 cattle money. The cattle driven and sold here are from the eastern part of the State, from the Rio Grande to the Red Rivers.

At Schuyler, this year, which was an experiment only, 27,000 cattle were sold. The First National Bank of Omaha handled $500,000 in consequence of this cattle business. I am informed by those who know that 40,000 more cattle could have been sold if they had been at Schuyler. Next year it is hoped the supply will reach 100,000, as the demand for Nebraska, Iowa, Southwestern Minnesota, and Dakota will certainly require that number.

Packing is one of the great means of disposing of the cattle of Texas. Allen & Poole, of Galveston, are packing immense numbers of cattle at Galveston, Indianola, and at Shreveport and other places. I am informed that they own more cattle than any other firm in the State. This salted beef finds market in our great eastern cities, with our navy and merchant marine, and in every beef-buying market of Europe.

Refrigerator cars are looked forward anxiously to, to take the place of live shipments as cheaper, healthier, and with no loss by long travel without food. If such shipments prove successful, every market east of the Missouri River and west of the Sierra Nevadas will receive beef from Texas.

Such is the colossal cattle-raising, driving, and shipping in and from Texas, built up where there were no markets and no railroads to stimulate it. What may we expect it to be now that there is a demand for it in every valley and on every prairie west of the Alleghany Mountains, and in every beef-buying market in the Atlantic States?

GENERAL REMARKS.

THE PLAINS.

At present one of the most important and interesting of the many questions relating to the great West is, How can the Plains be made useful to man? And this, so far as it relates to agriculture, involves two other inquiries, as follows: How much of it can be irrigated to that extent required for the production of useful crops? And how much of the remainder can be profitably used as pastoral lands? The answers to these questions are of no small importance in the political economy of the nation, but, on the contrary, deserve and should receive the attention of our statesmen. That which adds to the material wealth and productive energies of a nation is of far more importance than that which simply represents value, although the latter often receives more attention than the former.

Take, for instance, the broad belt of country situated between the 99th and 104th meridians, and reaching from the Big Horn Mountains on the north to the Llano Estacado on the south, containing about one hundred and fifty thousand square miles. Must this vast area remain forever unproductive and useless, without a vigorous effort being made to redeem it and make it valuable? If but one-fifth of it could be brought under culture and made productive, this alone, when fully improved, would add $400,000,000 to the aggregate value of the lands of the nation. And taking the lowest estimate of the cash value of the crops of 1869 per acre,* it would give an addition of more than $200,000,000 per annum to the aggregate value of our products.

But returning to the inquiries before us, I may state with all confidence, in answer to the latter, that the extent of the pastoral lands is fully equal to all the demands, for grazing purposes, of the population

*Agricultural Report, 1869.

that will ever occupy this region. The first inquiry cannot be correctly answered until we have received more data than at present in our possession. Yet the answer is not impossible, for it may be given with sufficient approximation for practical purposes. Let the following statistics be procured, and then the solution can easily be obtained by simple calculation.

First, the extent of the land sufficiently level for cultivation and irrigation upon which water can be brought from the streams of this section; *second*, the rate of the descent of these streams and of the plains across which they flow; *third*, the amount of the rain-fall during that portion of the year when it is needed to supply the growing crops with moisture; *fourth*, the volume of water that flows down from the mountains and enters upon the plains during the same season.

Sufficient statistics in the first, second, and third classes have already been obtained to indicate the result; but, before presenting these I may state, in order to limit our investigation as much as possible, that we may confine them to that part of the Plains lying west of the 99th meridian, as east of this the precipitation of rain is generally sufficient to supply the demands of agriculture, and it is more than probable that any deficiency that may exist there will be compensated by the increase that will probably occur when the water is more equally distributed over the western part of the Plains.

1. As to the extent of the level land. The answer may be given, in general terms, that this is equal to the utmost capacity of the streams that traverse this section; nor is it worth while to give particulars to prove this assertion, as a simple glance of the eye of the traveler, as he passes across this broad expanse, will satisfy him of its truth. One single view from a slightly-elevated point often embraces a territory equal to one of the smaller States, taking in at one sweep millions of acres. Eastern Colorado and Eastern Wyoming each contains as much land sufficiently level for cultivation as the entire cultivated area of Egypt.

2. Is the rate of descent of the streams sufficient to carry the water upon these lands? In my description of the various sections I have already answered this inquiry in part; but as these statements have principally applied to the country near the mountains, I will present some statistics which are sufficient to give a general answer on this point. The fall of the Arkansas from Cañon City to the mouth of Pawnee Fork (which is about the 99th meridian) varies from fifteen to eleven feet to the mile. This is sufficient, with a canal one hundred miles in length, to send its waters over a plain one thousand feet high. The average fall of the Canadian is about the same. From Denver Junction to Fort Hays, near the assumed meridian, the descent is nine feet to the mile; sufficient, with a canal one hundred miles long, to pour the waters of the South Platte on a plain six hundred feet high. The fall of the South Platte between Denver and its junction with the North Platte is about ten feet to the mile, and that of the North Platte from Fort Fetterman to the same junction is a little over seven feet to the mile. These figures give a favorable answer to the second inquiry, showing that the descent of the streams and plains is sufficient to allow even the higher table lands to be irrigated, leaving only the question of a supply of water. I have not brought into this investigation the inquiry in regard to the productiveness of the soil, for I take it for granted that wherever it can be irrigated it is productive.

Water is the thing demanded, the only element needed except the application of human energy, to render this broad area productive; Nature has supplied all the other elements, ready for use. But how much water is necessary? From the best records at hand we learn that the region around Washington City receives twenty-one inches rain-fall during the spring and summer months; that around New York, 23; the vicinity of Cincinnati, 25; Missouri, 26; Michigan, 18; and the region around Leavenworth, 20. But George P. Marsh,* following the statement of Boussingault, tells us that seventeen and one-third inches suffice for the sandy soil and dry climate of Egypt, counting one hundred and fifty days as the length of the irrigating season. As there is no rain there, this entire amount must be furnished by irrigation.

As shown by experience in Jumna, in India, a discharge of one cubic foot of water per second is sufficient to irrigate two hundred and eighteen acres—one hundred and fifty days here, also, being assumed as the irrigating season.† This is equivalent to about sixteen and one-third inches, to which must be added one-fifth, (the rain supplying one-sixth of the whole amount,) which gives a total of about nineteen and one-half inches. This varies but little from the estimate given by Marsh, and falls between the amounts as given for Michigan and Leavenworth. Assuming the amount given by Marsh to be a sufficient supply for the growing season on the Plains, we arrive at the third inquiry.

3. What portion of this is furnished by the rain-fall during this part of the year? We have but little data upon this point, yet sufficient is known to enable us to make an approximate estimate. The meteorological records kept at Fort Laramie, Santa Fé, and Fort Lyon (as given by Blodget, Foster, and Elliot) show the average rain-fall for the spring and summer, taken together, as follows:

Fort Laramie, 14.39 inches; Santa Fé, 11.73; Fort Lyon, 6.36. An average of these three places is 10.82 inches, which, deducted from 17.34, the amount of water necessary, leaves 6.52 inches to be supplied by irrigation. But I think this estimate of the rain-fall on the Plains is too large, and that a further examination of the more recent observations and records will reduce it. I judge that seven inches, or, to make the remainder a round number, 7.34 inches, will be much nearer the correct figure. Nor do I arbitrarily assume this average, but from incomplete data, not necessary to be repeated here. If too small, the calculations based upon it are certainly safe; if too large, the error will be much less than it would be if we assume the larger amount, and it must be very near the lowest possible average, which, for the dryest sections, is seldom placed less than five inches. This, then, will leave 10.34, or, in round numbers, ten inches to be supplied by irrigation.

4. Now, an answer to the fourth question—what is the volume of water brought down by the streams during the spring and summer?—would enable us to tell at once the area that can be rendered tillable by the aid of irrigation. But, unfortunately, at this point we are without reliable statistics. Few or no streams have been accurately measured with this object in view, and but few have even been roughly estimated. While in Italy and India this has been a matter of careful study; the necessity for irrigating any of our lands having been but recently felt, it has not been attended to. But the rapid influx of population into the great plains and mountain regions of the West is causing the importance of attention not only to this, but to all that bears upon irrigation, to be felt more and more each year.

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* In "Man and Nature."

† Smith's Italian Irrigation, vol. I, p. 378.

The rough estimate I made of the volume of water in the North Platte, near the Old Bridge, above Fort Fetterman, showed a discharge of about fourteen hundred cubic feet per second. The width at a narrow and somewhat rapid point was supposed to be about one hundred and sixty feet; the average depth two feet; the rate of the current about three miles to the hour. The river at this season (August) was low—at most, not more than two-thirds or one half its usual size in the spring. Supposing it to have been two-thirds, this would give, as the average discharge during the irrigating season, two thousand one hundred cubic feet per second. Calculating by the rule given by Captain Smith as applicable to the dryer sub-Himalayan districts—that one cubic foot per second irrigates two hundred and eighteen acres—we obtain the following result: As but ten-sixteenths of the water required there is necessary here, it follows that one cubic foot will irrigate 348.8 acres, or, in round numbers, three hundred and fifty acres. This gives the total amount which can be watered during the season of one hundred and fifty days, by a canal drawing off the water at this point, at seven hundred and thirty-five thousand acres, or nearly eleven hundred and fifty square miles. As no area, when most densely populated and in the highest state of cultivation, will ever require more than one-half of the land to be absolutely and fully watered each year, we may estimate the territory that can be brought into use by such a canal at one million four hundred and seventy thousand acres, or two thousand three hundred square miles; which would add at least $25,000,000 to the value of our real estate, and fully $10,000,000 to the yearly value of our productions.

Calculating by the method which Marsh has adopted, the result is very nearly the same. The daily distribution would be .067 of an inch; at which rate the area irrigated would be eleven hundred and seventy square miles, or about seven hundred and forty-nine thousand acres. These results show a difference of less than two per cent., which is somewhat remarkable considering the entirely different stand-points from which they start.

It may be argued that this calculation makes no allowance for the loss; but that it is based upon the assumption that all the water is made effective. This is a mistake, for it is based upon actual experiments, showing the flow of water necessary to irrigate a given area, including all loss except the absorption by the bottom and walls of the canals; and this in India, even in the sandy districts, does not exceed five per cent.

This calculation is certainly a safe one, as the rain-fall is reduced nearly one-third below that given by the authorities on the subject, and the lowest figures are used in regard to every other item. The point of the Platte selected for observation was favorable, as it presented about an average of velocity. Taking the average fall at only seven feet to the mile, if we follow the rule given by Dwyer in his "Treatise on Hydraulic Engineering," the velocity would be about two hundred and ninety-five feet per minute, while I have assumed it to be but two hundred and sixty four feet.

Another point connected with this subject, but upon which I have no information, is certainly worthy of investigation; it is this: What will be the result in the bed of the stream below the point from which the water is drawn? Will it contain only the water furnished by the tributaries entering into it below this point? In the tract of country in India lying along the base of the Siwalic Hills, both east and west of the Ganges, it has been noticed that, although all the water was drawn from the bed of the stream, below this water would commence issuing from the porous soil. So large is this supply in some instances, that the amount due to percolation in the Jumna is estimated at one thousand eight hundred and sixty cubic feet per second, while the total amount at the canal heads is placed at but three thousand four hundred and ninety cubic feet; showing a restoration by percolation of over fifty per cent. The same thing has been observed in Northern Italy. M. Lombardini states that the Ticino at Tornavento, the Adda at Cassanò, and the Oglio at Torre Pallavina, in times of great dryness, are entirely closed and exhausted. Yet, without the aid of any visible affluent whatever, the streams soon reappear, formed by new supplies derived from percolation through the banks and springs in the beds, so that they early again become navigable.

While it is not probable this would be the case at that distance out upon the Plains where the streams now begin to sink, yet there is nothing to forbid the presumption that it would occur nearer the mountains and along those streams which have their sources in the snowy ranges. But it is necessary to study carefully all these points before the agricultural capacity of the great West can be known.

In my estimates of the heights which might be reached by irrigating ditches I have confined myself to the rule generally adopted in the West, of giving to them a descent of from three to five feet to the mile. But the longitudinal slope of the Ganges Canal varies from twelve to fifteen inches; and the larger canals in Italy generally have a descent of from seventeen to twenty-four inches to the mile.

LAND GRANTS.

It may not be improper for me to say something in respect to the influence of land grants upon agriculture in this part of the West.

While I believe that the laws granting homesteads to actual settlers are wise and proper, and should not be abridged, yet I do not think that a fear of encroaching upon them should prevent such judicious grants in that section as would have a tendency to develop it. I am no advocate for the indiscriminate granting of land all over our country wherever asked for. But where there is a section which cannot be developed without some aid of this kind, then it is wise in the Government to bring it into use, if every foot of the soil be required to do it. The question in such places is reduced to this one point: Shall the soil forever remain idle and valueless, or shall it be brought into use by giving portions of it for its redemption.?

As remarked in the introduction, there are facts and principles which hold good in the rain-moistened sections which entirely fail in the West. In the former each quarter-section can be brought under cultivation without any other preparation than clearing it of timber, save the swamps and rugged mountains. But in the latter water must be brought to the lands by means of ditches and canals, which, as in the case of the higher levels and broader plains, often costs an outlay of thousands of dollars. Hence combination or capital is necessary, in order to do this at a reasonable cost per acre. The immediate bottoms of the streams can and will be brought into use chiefly by individual efforts, as here each farm can have its own acequia at a moderate expense. But these compose only a small proportion of the lands that are susceptible of irrigation and culture. The greater part of the remainder will require ditches or canals varying from five to fifty or more miles in length, yet by making these of proper dimensions and taking in as large a scope of country as possible, the cost per acre will often be less than that of the lower lands where each farmer digs his own ditch. Hence it is not to be presumed that a man of small means, who is seeking a homestead under the law, will attempt to settle in a place where such an outlay as this is required; and yet these lands when irrigated and cultivated will generally prove as productive as the bottoms which skirt the streams. No more likely is he to do this than he is to settle in a bog that must be drained at a heavy expense before it can be rendered tillable. Therefore, while I believe it is proper and right to give every possible inducement to actual settlers of small means, that they may have permanent homes of their own, I also believe that the chief impetus that can be given to bring about the settlement and development of these Territories will be by judicious land grants to colonies and railroad companies. I know there is a strong prejudice growing up in the minds of a large portion of the people against such grants, and probably not without reason; yet, while striving to avoid one extreme, an evil is seldom cured by running to the other. And while I would advocate limited and judicious grants in sections where irrigation is necessary, I do not include the giving of aid by money or subsidies, for these in the end generally do more harm than good, sometimes absolutely retarding that development of the country which would be made through the efforts of these companies without such aid. Nor, as a general thing, is it best to make grants to railroad companies along the valley of one large stream for any great distance, if the price of the alternate sections is thereby increased, as this would abridge the privileges of settlers and purchasers of small means. It would also present a strong temptation to the company to purchase the remaining sections and put up the price, and thus fail to accomplish the very object for which such grants should be made.

I believe the true policy, so far as the country immediately east of the Rocky Mountains is concerned, is to grant inducements to the construction of roads north and south, at such a distance from the base of these mountains as to compel the companies to cut canals of considerable length in order to bring their lands into market. For example, a very judicious grant might be made for a road from some point on the Kansas Pacific Railroad east of Denver, (fifty or one hundred miles,) by way of Cimarron Pass to Albuquerque, in New Mexico, if not allowed to run too close to the mountains. But the question may be asked, Why prevent it from running near the mountain base? Because here the land is easily irrigated, and will be settled without this aid, and, therefore, not only is such a grant unnecessary to the development of this section, but it abridges the rights granted under the homestead laws. Nor is it good policy, on account of the importance and influence of an intermediate town or locality, to bend to any great degree to meet this demand, for the importance of the place will ultimately give it a railroad connection without Government aid, thus increasing the railroad facilities under the same grant.

South of Albuquerque, any aid given should be for roads running east and west, rather than north and south, as here the general course of the streams is south instead of east. It would be improper for me, in this report, to attempt any lengthy argument to prove this position; nor is it necessary, for the careful study of any good map of this part of the West, by one not interested in land grants or railroads there, will convince him of the correctness of my position, if he takes agriculture as his stand-point.

Another judicious grant might be made for a road running from Cheyenne, or some point on the Union Pacific Railroad east of Cheyenne, north into Montana, following here also the rule before laid down, that is, not going too close to the mountains, and not allowing it to continue in the North Platte Valley for any great distance.

Such I conceive to be the true policy, looking at the matter from an agricultural point of view. But it may be said that the mining interests demand roads into the mountains, and that Government should foster this branch of industry as well as any other. This may be true in part, but I think the Government should look first to the development of that which has the most elements of permanency, and which, when once put in motion, will continue to grow and increase by its own inherent vitality, that which gives homes, happiness, and stability to its citizens.

And besides all this, if the main trunks are built along the plains parallel with the ranges, local interests will induce the construction of shorter lines into the mountains wherever needed. It is not worth while for me to elaborate these ideas, as the intelligent reader can readily see their bearings.

The instances given are only used as illustrations, as there are other sections where judicious grants might be made, and which would be the means of bringing into use large bodies of land which will long remain valueless without some aid of this kind. I mention these because they are within the bounds of the territory under consideration in this report. I might add, also, that a road from Salt Lake City to St. George, in Utah, would greatly assist in opening up a very important section, and would form one link in the great line which will some day traverse the length of the great inter-alpine trough from the Dalles to the mouth of the Colorado. And perhaps it might render valuable assistance in solving a troublesome question; and it is always better to cure an evil by benefiting, where it can be done, than by harsh measures, be they ever so just.

These roads, wherever they pass through Indian countries, would not only greatly lessen the expense of military transportation, but would also have a tendency to check their depredations. Therefore it is not wise for the Government so to bind itself by treaties that the right of way for railroads cannot be given through reservations. In fact, it is my opinion that the policy of making treaties with them, as quasi-nationalities, is detrimental to the agricultural development and best interests of the West. Perhaps I ought not to express my views so strongly on a collateral topic. But the Indian question does have a very important bearing on the subject of this report, and for this reason I shall briefly allude to it again.

It is possible that some general law might be passed which would induce colonies to settle isolated sections where bodies of arable land of limited extent are to be found. Something of this kind is certainly desirable in those portions of these Territories where there is no prospect of railroads being extended to them for some time to come. Assistance given by proper grants for the construction of leading canals, with reserved rights to the settlers on the reserved sections, would certainly be a means of bringing into market and into use large bodies of land which will otherwise remain for a long time idle.

INDIANS.

The present Indian policy, which doubtless looks forward to the localizing and settlement of these roving tribes, is intimately connected with the agricultural development of the West. Unless they are localized and made to enter upon agricultural and pastoral pursuits they must ultimately be exterminated. There is no middle ground between these extremes—one or the other must be the final result. If this be so—and I think it will be conceded by all who have given the subject any serious reflection—then it is very important that the agricultural capacity of the Territories, where they are to be found, should be ascertained as soon as possible, and the extent and locality of the arable district adapted to such settlement determined. But these roving sons of the Plains know nothing of agriculture, they know nothing of the principles of irrigation, and hence they must be taught, and to do this the locality for each tribe must be fixed, and the experiment tried. Some of the Indian agents, I believe, have entered upon this work, which, if properly managed, will in all probability result in more good than any other that has been tried. But if persuasion, after a thorough trial, fails to bring a tribe to terms, then compel them to it; for one restless, roving band may destroy all the good that might be effected with half a dozen others. Lend a helping, fostering hand to all that are willing to enter upon permanent settlements, but make no treaties and grant no annuities to those that refuse to come to these terms. If extermination is the result of non-compliance, then compulsion is an act of mercy. The how, I leave to others to decide. But looking at it from the agricultural side of the question, I certainly conceive it to be a necessity.

ARTESIAN WELLS.

The possibility of obtaining water upon the plains by means of artesian wells has engaged the minds of many persons for a number of years, but thus far the attempts have not proved successful. The one made by General Pope on the Llano Estacado, in New Mexico, is well known, but the failure in this case, if it can truly be called a failure, has not been sufficient to decide the question, especially in regard to that portion of the country lying north of the "Staked Plains," where the conditions are different.

The latest attempt of which I have any knowledge is the one recently made at Kit Carson, on the line of the Kansas Pacific Railway. The following account of this work I take from a recent communication on the subject to Dr. F. V. Hayden, from Mr. R. S. Elliot, industrial agent of this railroad company:

Strata passed through (including the wood conductor near the surface) are as follows:

	Feet.		Feet.
Conductor of wood from the surface	40	Gray sand rock	30
Blue mud	260	Black slate	100
Gray slate	700	Slate and shale mixed	100
Magnesian limestone	70	Black slate, (in which the boring stopped)	160
Total depth			1,460

Captain Grant, who has charge of the work, states that at the depth of three hundred feet a crevice was reached, another at three hundred and forty feet, and another at four hundred feet; and that at the depth of four hundred and fifty feet a flow of salt water was obtained, but that at no point has any fresh water been found. From the crevices struck, and from the size of the pieces of shale, slate, &c., brought up, he infers that the strata are inclined at a high angle. When the work stopped the water arose above the point at which it comes in, but how near the surface it stands has not been ascertained. Whether the company will continue its operations here, or not, has not been determined.

Although this experiment does not decide the question, yet on the whole the result is unfavorable, and indicates, to say the least, that to obtain flowing fresh water a great depth will be required. I am therefore inclined to think it is best not to count upon these as a means of increasing the breadth of tillable land.

I believe an attempt has been made at Lincoln, in Nebraska, but am not informed as to its progress or probability of success.

I.—A LIST AND DESCRIPTION OF NEW SPECIES OF ORTHOPTERA.

By Prof. Cyrus Thomas.

LIST.

GRYLLIDES.

Stenopelmatus, Santa Fé, New Mexico. Too much mutilated to be determined.
Gryllus abbreviatus, Serv. Found throughout eastern Colorado.
Oecanthus niveus, Harr. Found along the streams from Fort Fetterman to Raton Mountains.

LOCUSTARIÆ.

Anabrus Haldemannii, Girard. South Park, Colorado, and near Laramie River east of the Black Hills, Wyoming.
Anabrus Stevensonii, Thos. Northeastern New Mexico.
Anabrus minutus, Thos. Northeastern New Mexico.
Thamnotrizon (Anabrus) purpurasecens, Uhler. South Park, Colorado, and near Laramie River, east of the Black Hills, Wyoming.
Thamnotrizon trilineatus, Thos. Northeastern New Mexico, and South Pass, Wyoming.
Ephippitytha gracilipes, Thos. Southeastern Colorado.
Orchelimum vulgare, Harr. Found throughout the eastern part of Colorado and Wyoming.
Xiphidium fasciatum, Serv. Colorado.
Udeopsylla robusta, Hald. Throughout Colorado, Wyoming, and Utah.
Ceuthophilus divergens, Scudd. Hardscrabble Creek, Colorado, and Red Buttes, Wyoming.

ACRIDII.

Opomola neo-mexicana, Thos. Northern New Mexico, and along Cottonwood Creek, Wyoming.
Acridium flavo-fasciatum, De Geer. Southeastern Colorado.
Caloptenus bivittatus, Say. Colorado, Wyoming, and Utah.
Caloptenus spretus, Uhler. I have traced this species from the borders of Nevada and Idaho on the west, to Missouri and Iowa on the east, and from the Raton Mountains on the south to the Big Horn Mountains on the north, but have discovered its limits only toward the south and east.
Caloptenus femur-rubrum, De Geer. Common east of the Rocky Mountains.
Pezotettix borealis, Scudd. Mountains east of Middle Park.
Pezotettix picta, Thos. From Cheyenne south to the Arkansas River.
Brachypeplus magnus, Girard. Along the head-waters of the Arkansas, and near the Laramie River east of the Black Hills.
Boöpedon nubilum, Thos. Near Canon City, Colorado.
Boöpedon flavo-fasciatum, Thos. Southeastern Colorado.
Oedipoda Carolina, Linn. Found at a few points in Colorado, especially south of Denver.
Oedipoda corallipes, Hald. Colorado, Wyoming, and Utah.
Oedipoda aequalis, Say. Common in Colorado and Wyoming. This is an extremely variable species.
Oedipoda trifasciata, Thos. Common throughout Wyoming, Colorado, Northern New Mexico, and Northern Utah, on the elevated plateaus.
Oedipoda neglecta, Thos. Eastern Colorado and North Platte Valley, west of Fort Fetterman. I have also collected some specimens in Southern Illinois which appear to be identical with this species.
Oedipoda carlingiana, Thos. Colorado and Wyoming.
Oedipoda cincta, Thos. Southeastern Colorado.
Tomonotus Mexicanus, Sauss. New Mexico.
Tomonotus nietanus, Sauss. Southeastern Colorado and Southeastern Wyoming

Tomonotus pseudo-nietanus, Thos. Near Cañon City, Colorado, and near Fort Fetterman, Wyoming.
Stauronotus Elliotti, Thos. Colorado and Wyoming.
(*Gryllus*) *formosus*, Say. Southeastern Colorado. A new genus will have to be established for the reception of this species.
Acrolophitus hirtipes, Thos. Near Cañon City, Colorado, and at Fort D. A. Russell Wyoming.
Stenobothrus obionus, Thos. Southern Colorado.
Stenobothrus brunneus, Thos. Colorado and Wyoming.
Stenobothrus quadrimaculatus, Thos. Colorado and Wyoming.

DESCRIPTIONS.

Although most of the following species have been described by me, and the descriptions published in the "Proceedings of the Academy of Natural Sciences, Philadelphia," for 1870, (pp. 74–84,) yet it is proper that the descriptions should be inserted here, as they constitute a part of the work of the expedition. Those only will be marked as new which are here described for the first time.

I follow the arrangement adopted by Scudder in his catalogue, although it is not altogether the one I should prefer.

LOCUSTARIÆ.

ANABRUS, (HALD.)

The characters of this genus were not fully given by Professor Haldeman when he established it, and those subsequently added by Girard are scarcely sufficient to distinguish it from other closely allied genera. Having both sexes of three species, I give the following as the principal characters:

General character: Head large, smooth, advanced in front between the antennæ. Pronotum selliform, extending over the base of the abdomen; rounded and smooth; anterior portion of the sides reaching below the eyes; posterior margin and angles round. Prosternum bidentate; posterior angles of the meso-sternum elevated and acute. Elytra very short, having the form of scales in the males; covered by the pronotum in the females. Antennæ longer than the body, sometimes extending beyond the ovipositor. Eyes ovate; labrum round; maxillary palpi twice the length of the labial, the three outer joints nearly equal, terminal enlarged at the tip. Abdomen stout, of moderate length; the sub-anal plate of the male large, slightly notched at the tip, furnished laterally with filiform appendages which appear to be articulated at the base; the cerci (or substituted appendages) sub-cylindrical, enlarged and generally bifurcate at the extremity. Ovipositor long, bent beyond the middle. Cerci in the female small and generally hairy. Legs slender; posterior pair very long; femora enlarged next the body, but slender and straight beyond the middle, as long as the body (omitting the head); posterior tibia long as the femora, slender; all the tibiæ provided with four rows of spines, the anterior rows often scattered and irregular. A stout denticuloid process above the anterior coxa. The tarsi broad, soles concave; third articulation cordate.

This genus differs so slightly, in description, from *Thyreonotus* (Serv.,) that there is scarcely a necessity for its retention; but an examination of the species is necessary to decide this point. *A purpurascens* (Uhler) not having the prosternum spined, has been removed to *Thamnotrizon*, (Fisch.)

A. Stevensonii, Thos. Syn., *A. Stevensonii*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 75.)—Female: Purple mottled with yellow; form and coloring somewhat similar to *A. purpurascens*, (Uhler,) but smaller and slenderer in all its parts. Face white, the transverse suture below the front fuscus; tips of the mandibles piceous; palpi pale, the penultimate joints of the maxillary palpi striped with purple above; antennæ long and slender, reaching nearly to the extremity of the ovipositor, dusky; cranium cinereous, with the vertex, and a line extending back from each eye, dull white. Pronotum short, not carinated, a slight transverse incision near the front; two oblique dorsal impressions, dark and very narrow; surface smooth, lurid; a large black spot occupying the central portions of the sides behind the transverse incision; lateral margins broadly, and anterior margins narrowly bordered with pale yellow; posterior angles tipped with piceous black. Elytra hid beneath the pronotum. Abdomen dull purple, somewhat darker along the sides. Ovipositor slightly curved beyond the middle, piceous at the tip; cerci slender, hairy; beneath dull white. Anterior and middle legs short; femora slender and straight; posterior legs very long and slender; femora and tibiæ, each the length of the body, omitting the head; all pale purplish-yellow; femora smooth; tibiæ with spines irregularly placed on the angles, also on the rounded portion, black at the tips. The spine above the anterior coxa pale, slender, and bent abruptly downward.

Length 1.13 inches; pronotum .26 inch; posterior femora .93 inch; ovipositor .75 inch.

Habitat: Southern Colorado, on elevated grassy terraces near the mountains and the parks. Named in honor of Mr. James Stevenson, a member of the expedition, who has for a number of years accompanied Dr. Hayden in his western explorations, and has been a diligent collector of specimens in all departments of natural history.

A. minutus, Thos. Syn., *A. minutus*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 75.)—Male: Similar in coloring and appearance to the *A. Stevensonii*. Face mottled with purple; a dark spot below each eye; a narrow line running back from the upper corner of each eye; cranium cinereous; head somewhat covered by the pronotum. Pronotum short, rounded, smooth; transverse incision almost obliterated; oblique dorsal impressions irregular; dorsal portions cinereous; sides with a triangular black spot, interrupted by light spaces, broadly margined with dull white; lateral angles tipped with piceous-black. Elytra short, extending over the second abdominal segment; margins pale yellow, central portions brown. Abdomen cinereous, a darker line along the sides; notch of the sub-anal plate very small; appendages small, hairy; the tip of the last dorsal segment strongly bifid, denticulate. The cerci (I use this term for those appendages supplying the place of cerci) slightly bent, bifurcate. Legs same color as the abdomen and cranium; anterior pair quite short; the middle pair a little longer; the posterior very long, femora marked with a dark line along the upper carina; tibiæ slender, spines tipped with brown. Antennæ at least twice as long as the body.

Length, .75 inch; posterior femora, .62 inch; elytra, beyond the pronotum, .1 inch.

Female: Similar to the male in appearance, coloring, and size. Cerci small, hairy. Ovipositor bent, slightly narrowed in the middle; brown at the tip. Length as in the male; ovipositor, .55 inch.

Habitat: Elevated grassy terraces in Southern Colorado, South Park.

Some specimens of these two species have, on the under side of the posterior femora, about four or five abortive spines, especially the older or more mature ones. Sometimes the places of these spines are indicated by mere points, visible only under a glass. This fact may be important in fixing the position of this genus, which is evidently one of transition.

THAMNOTRIZON, (FISCHER.)

T. purpurascens, Thos. Syn., *Anabrus purpurascens*, Uhler. (Proc. Acad. Nat. Sci., Phila., p. —.)—I have removed this species from *Anabrus* because the prosternum is not spined, which must be a prominent character of that genus to retain the other species. The original description by Mr. Uhler is so full and clear that any addition is wholly unnecessary.

Found in South Park in considerable numbers, also in Wyoming, east of the Black Hills, on elevated plateaus.

T. trilineatus, Thos. Syn., *T. trilineatus*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 76.)—Female: Small, somewhat like *Anabrus minutus*, (Thos.,) but showing some important variations which place it in a different genus. Head moderate size, immersed in the pronotum nearly to the eyes; occiput very short, convex; vertex rounded between the antennæ, slightly advanced in front, this advanced portion triangular and deflexed; face short, broad, smooth and somewhat convex; labrum large, round. Palpi rather longer than usual, slender, cylindrical, terminal joint of the maxillary palpi longest. Pronotum small, rounded, not carinated; advanced in front over the back of the head, margin round, or sub-truncate; posterior extremity advanced over the base of the abdomen, round; sides narrowed below, reaching down about as far as the lower border of the eyes; posterior margin of the sides sloped quite obliquely, slightly sinuate. Antennæ reach the tip of the ovipositor. Ovipositor about the length of the body, slightly bent; cerci short, stout, covered with minute, depressed hairs; the plate between them triangular. Prosternum not spined. Anterior tibiæ with two spines in front; medial with two rows on the outside, 4 (counting the one at the base) and 2. Posterior legs wanting in the only specimen obtained.

Color (siccus:) testaceous green, striped and varied with pale yellow. Face testaceous, palest below, with a brown spot at each lower corner. Three pale, tolerably broad, yellow stripes reach from the head to the end of the abdomen; one along the middle of the back, and one along each side. Two oblique black marks on the back of the pronotum about the middle; lower margins of the sides yellow; beneath pale. Ovipositor fuscus. Antennæ dusky. Legs purplish; tarsi piceous.

Dimensions: length, .75 inch; to the end of the pronotum from the vertex, .34 inch; ovipositor, .73 inch.

Habitat: Southeast Colorado. Some specimens not yet examined, which may belong to this species, found near South Pass.

EPHIPPITYTHA, (SERV.)

This group, which is given by Serville as a sub-genus of *Phaneroptera*, is distinguished from the rest of the Phaneropteres by characters of sufficient importance to justify me in raising it to a genus. I have not examined a sufficient number of specimens to enable me to write out the generic characters in full, but will mention the following:

Pronotum selliform, somewhat scooped on the latter half, which is slightly elevated, and rounded; femora more or less spined; vertex tuberculate. Elytra and wings passing the abdomen, latter longest.

E. gracilipes, Thos. Syn., *E. gracilipes*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 76.)—Male: Small, slender; legs very long and delicate; occiput short, convex, terminating in a triangular tubercle at the vertex, not raised above the first joint of the antennæ, nor passing between them; face vertical, straight, flat, terminating upward just above the central ocellus in a sharp angle; ocellus situated exactly between the lower borders of the folds around the base of the antennæ. Pronotum sub-cylindrical in front, widened and elevated posteriorly; a slight transverse indenture each side, a little behind the middle; not carinated, but a medium line is visible along the dorsum; surface smooth. Elytra very narrow, nearly straight, passing the abdomen one-third their length. Abdomen sub-cylindrical; the sub-anal plate notched and bi-spinose; cerci stout, hairy, curved and mucronate; upper plate semicircular. Prosternum not spined; meso- and meta-sternum obliquely elevated at the posterior angles, obtuse.

Color (siccus:) pale yellow. A roseate stripe on the frontal tubercle; second joint of the antennæ orange-yellow; a bright yellow curved line runs from the upper canthus of each eye to the pronotum, where they meet with broader lines on the pronotum, which, converging posteriorly, fade near the middle of the dorsum. Anterior portion of the pronotum dotted with red. Stridulating organs very small, roseate. Elytra and wings pellucid. Abdomen minutely dotted with reddish-brown. Tips of the cerci black.

Dimensions: length, .75 inch; to tip of the wings, 1.25 inch; wings pass the elytra (about) .25 inch; femora, .1 inch; tibia, .95 inch.

Habitat: Southern Colorado. Unique specimen.

ORCHELIMUM, (SERV.)

O. vulgare, Harr.—The specimens I have marked as belonging to this species may prove to be new, as they vary considerably from the type.

CEUTHOPHILUS, (SCUDD.)

C. divergens, Scudd.—My specimens vary from the description of this species in having the hind femora of the females spined, the spines very short. There are also one or two slender spines on the front part of the anterior tibiæ not mentioned in Mr. Scudder's description, yet I think they belong to this species.

ACRIDIDÆ.

(*Truxalides.*)

OPOMOLA, (SERV.)

O. neo-mexicana, Thos. Syn., *O. neo-mexicana*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 77.)—Female: Long, slender, truxaloid. Head conical; occiput convex, ascending to the somewhat elevated vertex; vertex convex, ascending, sub-margined, rotund, rather elongate before the eyes; face very oblique; frontal ridge distinct, sides parallel, slightly sulcate; lateral carinæ distinct, obtuse, divergent, reaching the lower corners of the face. Antennæ strongly ensiform, triquetrous, reaching to the tip of the pronotum; inserted in deep foveolæ under the front of the cone. Pronotum about as long as the head; sides parallel; all its parts very regular; tricarinate, carinæ not elevated but distinct, all about equal; obtusely rounded anteriorly and posteriorly. Elytra a little shorter than the abdomen; wings a little shorter than the elytra. Posterior femora reach the extremity of the abdomen; very slender. Prosternal point short and obtuse, scarcely more than a pointed tubercle.

Color (immediately after being taken out of alcohol, in which it had been immersed for some months:) Face yellow, dotted with red; lateral carinæ rosaceous; on the top of the head a faint roseate stripe runs from the end of the cone to the pronotum, bordered on each side by a yellow stripe; from the lower part of each eye starts a bright-red stripe, which, running back across the head, continues along the upper portion of the side of the pronotum to its extremity and is lost on the elytra. Median carina of the pronotum red, the dorsal spaces yellow; lower portion of the sides yellow. Elytra semi-transparent; base and stripe along the dorsal margin roseate. Wings transparent; veins ochreous. Abdomen dull yellow, reddish on the basal segments. Legs rufous; posterior femora have a pale stripe along the upper edge; spines of the posterior tibia tipped with black.

Dimensions: Length 1.62 inch; to tip of elytra 1.50 inch; to extremity of the pronotum, .52 inch; femora, .88 inch; tibia, .86 inch.

Habitat: Northeast New Mexico.

I have not seen the male. This species comes near *O. mexicana*, (Sauss.,) but differs from it in the following respects: The antennæ are not rotundate, but sharply triquetrous; the pronotum is carinate, although the carinæ are but raised lines, yet very distinct; and although the posterior lobe is minutely punctured, the pronotum cannot be truly called "densely punctate." It approaches closely to *Truxalis*.

(*Mucronati.*)

PEZOTETTIX, (BURM.)

P. picta, Thos. Syn., *P. picta*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 78.)—Medium size, body elongate, stout sub-cylindrical, occiput convex; vertex deflexed, flat and narrow between the eyes, suddenly expanding in front, this advanced portion transverse and triangular; the frontal ridge somewhat convex, with a very slight depression at the central ocellus; eyes large, prominent, oval; antennæ filiform, nearly as long as the head and thorax. Sides of the pronotum parallel in the male, and very slightly divergent posteriorly in the female; carinæ obliterated by the sub-cylindrical form; posterior margins of the sides obliquely sloped, but not sinuous; posterior angle rounded; a slight transverse incision each side close to the front margin; the three usual transverse incisions distinct, crossing the dorsum in the female, the posterior one only crossing in the male; anterior margin and posterior lobe densely punctate, remainder smoother and sparsely punctate. Elytra very small, oblong-ovate, reaching the tip of the second segment; not meeting on the back; nerves reticulate, prominent, wings minute. Posterior femora stout, short, not reaching the extremity of the abdomen. Sub-anal plate of the male recurved with a kind of tubercle or prominence on the convex surface; upper plate falcate; cerci small. Prosternal spine stout, conical.

Color (siccus:) alternating rings of dark purple and white. The dark stripes are placed as follows: down the frontal ridge; on the occiput; down each cheek; two interrupted broad stripes running obliquely upward and backward from the anterior margin and angle of the pronotum; four spots on the base of each dorsal, and two on each ventral segment of the abdomen, (sometimes running into a continuous ring;) posterior femora crossed by three broad bands. The nerves of the elytra white, the spaces black. Colors of the male and female the same.

Dimensions: Female—length, 1.30 inch; femora, .6 inch; pronotum, .28 inch. Male—length, .95 to 1 inch; femora, .5 inch; pronotum, .26 inch.

Habitat: From Cheynne south to Raton Mountains, on the plains and foothills at the eastern base of the range.

When living this is a very pretty insect, the dark stripes being margined by red, which fades when immersed in alcohol, the black also becoming paler and assuming a purplish cast. This may possibly belong to *Dactylotum*, Charp, but I am not fully acquainted with the characters of that genus.

(*Mutici.*)

BRACHYPEPLUS, (CHARP.)

As Charpentier, at the time he established this genus, failed to give its characters, and the description of Girard is so short and deficient, I give, from a large number of specimens, what I conceive to be the distinguishing characteristics.

Generic characters: Body very robust, acridoid. Occiput broad, convex, smooth; vertex margined; frontal ridge broad, short, slightly sulcate, expanding below; lateral carinæ distinct, with a sulcus behind each; antennal foveolæ deep, oblong; cheeks prominent. Pronotum large, elongate, tricarinate; carina distinct, continuous; widest below, expanding posteriorly, sides straight, generally chagrined above, with the sides glabrous; no transverse incisions on the dorsum; anterior margin rounded, extending slightly on the head; posterior margin round. Elytra and wings rudimentary, (in the known species.) Legs very robust; posterior femora long as the abdomen, swollen; tibiæ strongly spined nearly the entire length. Antennæ filiform, joints distinct; long as the head and thorax. Sub-anal plate of the male tumid entire; cerci very short; female appendages stout, broad. Palpi short, joints all enlarged at the tip; the three outer joints of the maxillary palpi nearly equal, the ultimate a little the longest. Prosternum neither spined nor tuberculate. Abdomen somewhat compressed, carinated above. A well-marked and distinct genus.

B. magnus, Girard. (Marcy's Expl. Red River of Lous., p. 260, Pl. XV, figs. 1–4.)—This ponderous species is easily recognized by the figures referred to, but the description is quite deficient; therefore, to aid future investigations, I give it more minutely.

(Siccus.) Yellow, spotted with brown. Occiput convex, very slightly scabrous, an indistinct line running along the middle to the vertex, a few fine shallow punctures visible; the elevated margins of the vertex meet in about a right angle at the front; frontal ridge, although narrow above and gradually expanding as it descends, is not narrowed opposite the antennæ; margins distinct, obtuse; sulcus shallow, expanding and fading below, punctured. Pronotum with three distinct, continuous piceous carinæ; dorsum strongly chagrined, yellowish, with æneous luster; sometimes, especially in the females, there is a yellow line along each margin of the dorsum; sides purplish at the upper angles, yellowish below. Elytra ovate, reaching the third abdominal segment; nerves longitudinal, slightly branching near the extremity; light brown, spotted with black. Wings very small, yellow. Abdomen marked with a brown spot each side of each segment; each segment is also margined with a row of white dots. Legs as described by Girard.

Dimensions: Length, (female,) 2 inches; pronotum, .55 inch; elytra, .3 inch; femora, 1.25 inch. Males about one-fourth less. Size varies considerably.

Habitat: From Fort Laramie south to Santa Fé. The green and brown varieties were both observed; but after being immersed for some time in alcohol these colors fade, and all distinctions between the two are lost.

BOÖPEDON, (THOS.)

Generic characters: Has somewhat the appearance of *Pezotettix*. Body robust. Head large, exceeding the thorax in width, widest below; seen from the side presents a somewhat semicircular outline, deflexed below; occiput convex; vertex sloping, broad, sometimes exhibiting a shallow foveola, usually rhomboidal, with a slight median carina; frontal ridge prominent, not sulcate, margins obtuse and nearly parallel. Antennæ nearly as long as the head and thorax, inserted in deep, oblong foveolæ. Pronotum of medium length, sides parallel; subtruncate in front; posterior angle obtuse; three transverse incisions; the posterior about the middle, cutting the median carina; median carina distinct, but not elevated; lateral carinæ obsolete. Elytra shorter than the abdomen in the female, about the length of the abdomen in the male; inflated near the base, narrowed at the apex; two longitudinal veins dividing the entire surface into three nearly equal fields. Posterior femora stout, narrowed at the tip, passing the abdomen; tibia spined, enlarged at the tip. Ultimate joint of the maxillary palpi enlarged at the end, truncate. Prosternum with the anterior half tumid; the latter half cleft by a longitudinal sulcus. Pectus sub-convex or flat. Anal appendages of the female short and obtuse; sub-anal plate of the male keeled, trigonal, and turned up.

This is a very distinct genus, having a somewhat acridoid appearance, and forming, perhaps, the closest link between the *Mucronati* (*Acridii genuini*) and the *Mutici*, (or *Odipodes*,) and in a strictly natural arrangement should precede *Brachypeplus*. It would connect between the *Pezotettigi* or *Calopteni* and the *Stenobothri*.

B. nubilum, Thos. Syn., *B. nigrum*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 83.)

Gryllus nubilus, Say. (Jour. Acad. Nat. Sci., Phila., IV, 308. Entom. N. Am., Ed. Le Conte, II, 237.)—Having carefully examined the section where Mr. Say found his species, I do not know what insect he refers to, unless this be the one. But when he remarks "that it ascends into the atmosphere in great numbers," he certainly cannot allude to this species, unless he refers to the short flights of the males as they poise themselves in the air, a well-known habit of the *Oe. æqualis*, and some other species. There is another black species found in the same section, which flies much in the air, (*Tomonotus Nietanus*, Sauss.,) but its bright red wings, so apparent during flight, and its ample elytra, would seem to forbid the supposition that this was the species intended. Yet I cannot explain Mr. Say's remark, unless he has confounded the two.

As his description is rather short I will add some other points, chiefly from my description, under the name of *B. nigrum*, in the Proc. Acad. Nat. Sci., Phila.

Medium size, female much larger than the male.

Female: Occiput smooth, a few punctures on the vertex, a faint median line visible; eyes about midway between the front and back margins; frontal ridge convex, with a very slight indentation at the ocellus, punctured on the margins, reaching nearly to the cross suture, where it suddenly expands; lateral carinæ distinct, obtuse, sinuate and divergent; a deep sulcus below each eye. Pronotum nearly as broad as the head; median carina distinct, straight; posterior lobe punctate; central portions of the sides levigate; cross incisions one and two not reaching the median carina. Elytra narrow, covering about two-thirds the length of the abdomen, lanceolate; the two longitudinal veins strong, approaching each other at the apex along the external margin; the reticulate veins coarse. Wings shorter than the elytra.

Color (siccus): Dark ferruginous; lower angles of the face and side of the labrum black; tips of the elytra black; apex of the wings dusky, rest transparent; two reddish spots inside the posterior femora; tibia transparent red.

Male: Similar in coloring, only darker. Elytra black, somewhat paler at the base; wings transparent, cloudy at the apex.

Dimensions: Female—length, 1.5 inch; pronotum .35 inch; elytra, .55 inch; femora, .95 inch; tibia, .80 inch. Male—length, .87 inch; pronotum, .25 inch; elytra, .55 inch; femora, .62 inch; tibia, .56 inch.

Habitat: Southern Colorado and northern New Mexico; mostly in the valleys near the mountains.

[NOTE.—I regret very much two mistakes that occur in my paper published in the Proceedings of the Acad. Nat. Sci., Phila., 1870, July. One occurs on page 80, where I have described as a new species, under the name *Oe. pruinosa*, Say's *Gryllus trifasciatus*, which is not only sufficiently described for identification, but is also figured. The other mistake is on page 83, where I have described *Gryllus nubilus* of Say as a new species, under the name of *B. nigrum.* I had examined them and determined them, and laid them aside for the purpose of referring them to their proper genera and had marked the place in Say's Ent. where they are described. Having to close up my article rapidly, preparatory to my departure west, forgetting these facts, and finding them among those examined and to be described, I proceeded to describe them without further examination. A few days after I became aware of the mistake and immediately wrote a letter to Dr. Hayden, making the correction, and forwarded it to him at Washington, as I had forwarded the original manuscript through him, but it did not reach him in time. The synonyms will now have to stand, and I sincerely trust they may be the only ones in that paper.]

B. flavo-fasciatum, Thos. Syn., *B. flavo-fasciatum*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 84.)—Female: Carving and figure much the same as the female of *B. nubilum*, differing only in this, that the anterior transverse incision (1) being more indistinct, and the incision on the side of the pronotum near the front more distinct. Central foveola of vertex very shallow, divided into two parts by a slight median carina; frontal ridge convex, sparsely punctured.

Color (siccus:) Yellow, varied with brown. Head, yellow; lower angles of the face black; a very distinct yellow line, starting from the upper corner of each eye, reaches the posterior margin of the pronotum, bowing inward near the middle, bordered on each side by an irregular, dark-brown line; a dark line borders each eye posteriorly. Median carina of the pronotum dark brown or piceous black; the transverse incision black; rest of the pronotum brownish, palest on the sides. Elytra formed as in *B. nubilum*, brown, a pale-yellow stripe near the upper and lower margins of each, the upper having a notch on its lower side; three oblong yellow spots in a line or row along the middle, and a few smaller spots of the same color near the apex; they reach the third abdominal segment. Wings transparent, dusky at the tips. A brown stripe along each side of the abdomen, near the dorsum; a yellow spot in it on each segment near the upper border. Venter, yellow.

Male: Unknown.

Dimensions: Length, 1.5 inch; pronotum, 38 inch; elytra, .50 inch; femora, .85 inch; tibia, .76 inch.

Habitat: Found with the preceding, but a much rarer species. At first glance, when seen hopping among the grass, the collector is apt to take it for the pupa of *Calop. bivittatus*.

OEDIPODA, (LATR.)

Oe. corallipes, Hald. (Stans. Rep. Salt Lake, p. 371, Pl. X, fig. 3.)—Dimensions: Female—length, 1.80 inch; femora, .90 inch; tibia, .75 inch; to tip of elytra, 2 inches. Male about two-thirds the size of the female.

Habitat: Colorado, Wyoming, and Utah.

The bright vermillion tint of the posterior legs fades in alcohol. I am inclined to believe that *Oe. pardalina* (Sauss.) is synonymous with this species, but do not feel satisfied to decide positively on this point.

Oe. trifasciata, Thos. Syn., *Oe. pruinosa*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 80.)—*Gryllus trifasciatus*, Say. (Amer. Ent. III, Pl. XXXIV, fig. 3. (Ed. Le Conte, I, 78, Pl. XXXIV, fig. 3.)—The figure given in the edition by Dr. Le Conte is not a good one, nor, indeed, does it correspond with the description, which is somewhat minute. I give the following description, which I think will be sufficient to identify the species:

About the size and somewhat similar in coloring and appearance to *Oe. aequalis*, (Say,) but rather broader across the meso and meta thorax; head, viewed from the side, oblong; occiput convex, ascending; vertex broadly triangular, flat, not foveolate, declined, slightly margined and slightly contracted between the eyes; margins continuous with the frontal ridge; frontal ridge prominent, rounded above and somewhat sulcate below, expanding at the ocellus; lateral carinæ distinct, sinuous, and divergent below, (in the males these carinæ are more distinct and extended than in the females). Pronotum short, sub-cylindrical in front, expanded and more angulate posteriorly; cross incisions 1 and 3 distinct, 2 very indistinct in the males, apparent on the sides in the females, 1 arcuate above, 3 slightly sinuous and situated about the middle of the pronotum; median carina merely a raised line; lateral carinæ obliterated in front, obtuse on the posterior lobe; truncate in front, posterior angle obtuse. Elytra and wings considerably longer than the abdomen. Posterior femora broad, not reaching the extremity of the abdomen, Antennæ stout, central joints lengthened and distinct; reaching the middle of the abdomen in the males, a little shorter in the females.

Color (siccus): Varies considerably; that which is described as green by Say is often yellowish in the living insect, and pruinose after immersion in alcohol; and that part of the head and thorax described by him as brown often being a pale lilac, or mouse color. The intermediate cross band on the elytra is the broadest and darkest of the three. The posterior femora are often pruinose at the base. (My remarks apply to those dried after immersion in alcohol).

Since writing the description published in the Proceedings of the Academy of Natural Sciences, Philadelphia, 1870, p. 80, I have had an opportunity of examining a number of specimens taken at widely different points in the West, and find the species is subject to considerable variations, some specimens approaching so near *Oe. aequalis* that it is almost impossible to distinguish them from that species, if we rely upon color.

Dimensions: Male—length, 1.10 inch; to tip of elytra, 1.42 inch; pronotum, .26 inch; femora, .60 inch; tibiæ, .58 inch. Female—length, 1.48 inch; to tip of elytra, 1.70 inch; pronotum, .34 inch; femora, .76 inch; tibiæ, .70 inch.

Habitat: Found throughout Wyoming, Colorado, Utah, and Northern New Mexico, on the elevated table lands and ridges.

[NOTE.—For explanation in regard to my unfortunate mistake in describing this species as new, and thus adding another synonym to the already too long list, see previous note under *Boöpedon nubilum.*]

The female is seldom pruinose; occiput, brown; pronotum, reddish-brown, varied with dots and lines of yellow. The posterior lobe of the pronotum in each sex is densely punctured, but that of the female intersected by irregular, slightly-raised lines.

Oe. cincta, Thos. Syn., *Oe. cincta*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 80.)—Female: Very similar in appearance and coloring to the male of *Oe. aequalis*, (Say,) but in the carvings of the head approaching the *Tomonoti*, (Sauss.,) of which *Oe. sulphurea* (Burm.) may be taken as the North American type. The vertex channeled; the margins strongly and sharply elevated, waved, descending; truncate squarely in front; a slight median line visible. Frontal ridge vertical, straight, sulcate, narrowed immediately below the antennæ, expanding at the base, reaching the transverse suture; lateral carinæ distinct, divergent. Pronotum rugose, tricarinate, truncate in front, angled at the posterior extremity; median carina only a raised line, cut by incisions 1 and 3; lateral carinæ distinct on the posterior lobe, obliterated in front, coarctate in front, expanding posteriorly; incision 3 situated before the middle. Elytra narrow, passing the abdomen one-third their length. Wings nearly the same length. Posterior femora not passing the abdomen. Antennæ passing the pronotum slightly.

Color (siccus): Rusty brown, varied with lighter and darker shades. Face and the sides of the pronotum yellow, mottled with brown; two black bands pass round the front, one immediately above, and the other just below the antennæ, (the lower a little broader than the upper;) converging behind these, they pass through the eye (plainly to be seen in a fresh specimen) and become a single black stripe behind the eye, which reaches to the posterior incision of the pronotum, decreasing in width as it passes along the lateral angle. Pronotum ash-colored on the dorsum; posterior lobe palest, with minute brown tubercles scattered over it; a dark-brown spot on each side. Elytra brown, darkest next the base; semi-transparent at the apex. Wings transparent, yellow next the base; apical half dusky; this dark marginal band is broad in front, tapering toward the inner angle but does not reach it; stretches along the front sub-margin nearly to the base; is somewhat darker at the inner and outer borders, reaching to the apex. Posterior femora reddish with two oblique darker bands on the outer face, and three black bands inside.

Dimensions: Length, 1 inch; to tip of elytra, 1.26 inch; to end of pronotum from vertex, .31 inch; femora, .54 inch; tibiæ, .44 inch.

Habitat: Northeastern New Mexico.

Oe. carlingiana, Thos. Syn., *Oe. carliniana*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 81.)—Female: This species at first sight has much the appearance of *Oe. carolina*, (Linn.,) but an examination of the head or thorax, or spreading the wings, will soon undeceive the observer. Although a little smaller than that species, it is more robust, compared with its length. The carving of the head is much the same as *Oe. corallipes.* Occiput short, sub-convex, not ascending; vertex very broad, slightly deflexed; the broad, shallow, central foveola divided by a median carina into two elongate pentagonal spaces, the median carina and margin next the eye being the longest sides; the lateral shallow foveolæ triangular; at the top of the frontal ridge is a lunate depression; frontal ridge somewhat broad, obtusely margined, expanded at the ocellus, vertical, reaching the cross suture; lateral carinæ distinct, reaching the corners of the face. Antennæ filiform, sub-planate. Pronotum subcylindrical in front, flat on the posterior lobe, expanded posteriorly, not constricted; median carina, a raised line, cut by the cross incisions 1 and 3; posterior incision before the middle; lateral carinæ obliterated in front, but distinct on the front of the posterior lobe; posterior lobe densely punctate. Elytra and wings extend slightly beyond the abdomen. Posterior femora short, not reaching the extremity of the abdomen; inflated.

Color (siccus): Ash-colored; vertex and posterior lobe of the pronotum tinged with reddish brown. Elytra opaque and somewhat brownish at the base, semi-transparent at the apex; dotted over with pale brown. The wings, when fully expanded, present a very broad fuscus band across the base, parallel with the body, the outer border lying a little beyond the middle of the wing, (when thus expanded;) a large triangular space at the apex transparent, with dark and white veins. Posterior femora spotted with black inside; tibiæ yellowish.

Male: The male differs only in size, and in having the elytra crossed by irregular brownish bands, somewhat as in *Oe. aequalis*, but less distinct.

Dimensions: Female—length, 1.38 inch; to tip of the elytra, 1.58 inch; to tip of the pronotum, from the vertex, .45 inch; femora, .64 inch. Male—length, 1.16 inch; to tip of elytra, 1.36 inch; to tip of pronotum, .42 inch; femora, .58 inch.

Habitat: Found in Colorado and Wyoming; somewhat rare in the former, but abundant in the latter. It varies considorably in color, sometimes assuming a very distinct purplish tinge throughout, but especially on the elytra and wings; at other times a pale, dirty yellow, with the spots on the elytra wanting. The purplish variety I observed only in Wyoming, between Chugwater and South Pass. This species belongs to that group of Oedipodes of which the *Oe. aequalis* (Say) may be taken as the type; to this belong *carolina* at one extreme, and *trifasciata* at the other, *aequalis*, *carlingiana*, and perhaps *cincta* and some others.

Oe. neglecta, Thos. Syn., *Oe. neglecta*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 81.)—Female: Much like *Oe. corallipes*, (Hald.,) being about the size of the male of that species, for which it has doubtless often been taken. In its carvings, as well as size, it comes very near *Oe. mexicana*, (Sauss.) Vertex very broad, transverse, foveolate; the large central foveola divided, by the recurving margins, into three contiguous foveolæ; these margins, seen from the front, form a W, with a line across the middle angle; lateral foveolæ obsolete; frontal ridge bisulcate above the ocellus, sulcate below, expanded at the ocellus. Pronotum flat above and rough; median carina a raised line, very distinctly severed by cross incision 3, before the middle; incisions 2 and 3 come together at the median carina; anterior portion rugose; posterior lobe covered on the dorsum with elongate tubercles, its sides granulose. Elytra and wings extend beyond the abdomen. Antennæ filiform, reaching the extremity of the pronotum. Posterior femora about the length of the abdomen.

Color (siccus): Dirty brown, with fuscus spots. Each elytron has a narrow yellow stripe near the dorsal border; base brown, fading toward the apex, which is semi-transparent; marked with groups of fuscus spots, which, at two points, are grouped so as to form irregular bands. Wings yellow at base; a dark band of moderate width crossing just beyond the middle, curving inward to the posterior angle; apex transparent, veins dusky. Posterior femora crossed on the outside by two very indistinct, oblique, reddish bands; inside, beneath, and tibiæ orange yellow; spines of the tibiæ tipped with black. Antennæ pale at base, apical portion dusky.

Dimensions: Female—length, 1.16 inch; to tip of elytra, 1.38 inch; to end of pronotum, from vertex, .44 inch; femora, .63 inch.

Habitat: Northeast New Mexico, Colorado, and Wyoming. Since my return home, I have taken here (Southern Illinois) some specimens which appear to belong to this species.

This species agrees so nearly with *Oe. mexicana* (Sauss.) that I would have marked my specimens as such, but for the fact that the wings are yellow at the base.

STAURONOTUS, (FISCHER.)

S. Elliotti, Thos. Syn., *S. Elliotti*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 82.)—Male and female: Medium size, robust, sub-angulate. Head large, widest below; face sub-vertical, strongly deflexed below the transverse suture; occiput convex; vertex slightly declined, foveolate; foveolæ shallow, the central broad, the lateral triangular, the points of the three meeting in a sharp angle midway between the upper angle of the eye and the base of the antennæ; frontal ridge not sulcate, narrowed above; lateral carinæ distinct, strongly divergent below; eyes medium size, ovate. Pronotum short, sub-truncate in front, posterior angle obtuse and rounded; the three transverse incisions distinct and closely approximate, 1 shortest, 2 and 3 connect at their termini on the side of the pronotum by an oblique depression; incision 3 about the middle of the pronotum; median carina distinct, not elevated; lateral carinæ distinct on the anterior lobe, and front part of the posterior lobe; the spaces on the anterior lobe between the median and lateral carinæ depressed like shallow basins. Elytra and wings about as long as the abdomen. Posterior femora inflated near the base, attenuate near the tip. Pectus not broader than the head. Antennæ filiform, reaching the end of the pronotum. Anal appendages of female very short and blunt. Color (siccus) yellow, varied with brown. Head yellow, occiput dotted with brown, sometimes forming imperfect waved lines; antennæ pale at the base, remainder brown. Pronotum with a yellow cross on the back; beginning at the lateral angles of the posterior lobe, the stripes converge anteriorly, and, crossing about the middle, fade on the anterior lobe; a triangular brown spot, between these stripes, on the posterior lobe; sides brownish, fading below. Elytra brown, a yellow stripe along the inner margin; lower half dotted with dark brown. Wings transparent, veins white except at the apex, where they are dusky. Posterior femora yellow, with two or three oblique brownish spots near the upper edge, which cross and become distinct bands on the inside; knee brown; tibiæ dusky above and at the tips, rest yellow; (I think bluish in the living specimens.)

Dimensions: Female—length, 1.07 inch; to tip of the elytra, 1.10 inch; to end of pronotum, .34 inch; femur, .62 inch. Male—length .88 inch; to tip of elytra, .88 inch; femur, .60 inch.

Habitat: Colorado and Wyoming.

Named in honor of Mr. Henry W. Elliott, artist of the expedition, who, in addition to his arduous duties, was constant in his efforts to collect specimens of natural history, and who rendered me valuable assistance in collecting plants and insects.

This sub-genus of Fischer (Orthop. Europ., p. 351) I have here given as a genus, as the distinguishing characters are sufficient to separate it from *Stenobothrus. Hippopedon* (Saussure) approaches rather too near this genus to remain as a separate group.

ACROLOPHITUS, (NOV. GEN.)

Generic characters: Œdipodiform, head pyramidal, apex directed upward. Occiput narrowed anteriorly, ascending; vertex pyramidal, triangular, pointing upward between the eyes and antennæ; eyes ovate, placed high and well forward; face vertical, carinated; frontal ridge, sulcate. Maxillary palpi medium length, terminal joints sub-equal, rather short; labial palpi proportionally longer, ultimate joint longest. Antennæ stout sub-planate, basal joint very large, triangular, inserted in deep oblong foveolæ under the pyramidal vertex; medium length. Pronotum of moderate length, coarctate; posterior lobe with the median carina elevated in the form of a crest arcuate on the top, the sharp posterior angle extending over the base of the elytra; the anterior portion rounded on the dorsum, not carinated; the three transverse incisions distinct, two sinuous, three bent abruptly forward round the point of the crest. Elytra narrow, reaching beyond the abdomen; wings ample; legs long, slender, and pilose. Prosternum not spined; pectus narrow.

A. hirtipes, Thos. Syn. *Gryllus hirtipes*, Say. (Amer. Ent., III, Pl. XXXIV, Le Conte's Ed., I, 78, Pl. XXXIV, Fig. 1.)—The description given by Mr. Say, with the figure, will enable the entomologist readily to determine this species. The figure gives rather too dark a shade to the abdomen and thorax, which is also the case with the next figure on the same plate, (*Gryllus formosus;*) the color of these parts varies from a pale greenish yellow to a brownish yellow. I have formed the genus *Acrolophitus* for the reception of this species, which should no longer remain buried in the old genus *Gryllus*, which is now restricted to proper limits. I may be permitted to remark here that I had the good fortune while in Colorado to pass over the same ground traversed by Mr. Say, and to obtain specimens of all the species of *Gryllus* described by him, viz: *aqualis*, *bivittatus*, *formosus*, *hirtipes*, *nubilus*, and *trifasciatus*. All of these have now been placed in modern genera, except *formosus*, for which probably a new genus will have to be formed.

TOMONOTUS, (SAUSS.)

T. nietanus, Sauss. (Orthop. Nov. Amer. II, 24. Rev. et Mag. de Zool., 1861, p. 321.)

T. mexicanus, Sauss. (Orthop. Nov. Amer. II, 23. Rev. et Mag. et de Zool., 1861, p. 321.)—I have specimens of two species of *Tomonoti*, which, I think, belong to the species thus named by Saussure; they certainly agree very closely with his short descriptions. The *T. nietanus*, when living, appears quite black; its bright-red wings being visible at a considerable distance when flying, and the sharp notes of the males being easily recognized by the ear which has once heard them. It is closely allied to the *Oe. sulphurea* Burm, which belongs to this genus; the notes of the male of this species can also be recognized by the practiced ear. It is possible that the notes of the males may, under some circumstances, enable us to determine whether certain differences are specific or only of variety.

The generic characters by which Saussure proposes to distinguish this genus are not well chosen, as they scarcely cover the group he evidently intended to embrace; nor is the gap between *Oedipoda* and *Gomphocerus* or *Tragocephala* quite broad enough for the insertion of a genus between them. Before a true natural arrangement can be obtained the species of these genera and of the heterogeneous *Oedipoda* will have to be thrown together and then separated into groups by other characters.

T. pseudo-nietanus, Thos. Syn., *T. pseudo-nietanus*, Thos. (Proc. Acad. Nat. Sci., Phila., 1870, p. 82.)—Male: Size and appearance much like *T. nietanus*, (Sauss.,) from which it differs only as follows: The facial costa is slightly broader and less excavated below the ocellus; the occiput and pronotum less rugose; the antennæ nearer cylindrical. The color is darker, the sides being deep-black throughout to the extremity of the elytra; the posterior part of the occiput and dorsum of the pronotum an ashy yellow, the front lobe and lateral margins of the pronotum dotted with black; the upper edge of each posterior femur has two yellow spots, the one next the base the larger; the entire under surface a shining black; wings, as in *nietanus;* base rosaceous; posterior margin broadly margined with black, and a facia of the same running along the anterior sub-margin nearly to the base.

Dimensions. Male: Length, 1 inch; to tip of elytra, 1.25 inch; femur, .67 inch.; tibia, .53 inch.

Habitat: Found near Canon City, Colorado, close to the mountains in a cañon; also near Fort Fetterman, Wyoming. I have not seen the female. This may possibly be a variety of *T. nietanus*, but from the permanent difference in the color of the pronotum, and from the fact that it was found at but one point in Colorado, and over a very limited territory in Wyoming, while the other was found more generally distributed on the Plains, I conclude it is a different species.

[NOTE.—While passing from Fort Fetterman to Red Buttes, in Wyoming, we encountered a vast swarm of *Caloptenus spretus*, not flying but on the ground pairing. I noticed here, as I had under similar circumstances before, that where these were very numerous, few specimens of any other species were to be found. In this case almost the only species to be seen were *T. nietanus* and *Oc. trifasciata*, whereas but a few miles back other species could be found in abundance.]

STENOBOTHRUS, (FISCHER.)

a. Antennæ filiform or sub-filiform.

b. Lateral foveolæ obsolete.

[NOTE.—It was with some hesitancy that I concluded to describe any of the species which appear to belong to this genus. Although Fischer is generally very careful and exact, the characters of this genus, as given by him, show the difficulty he has fallen into by clinging too closely to variations in a given part. The consequence is that this genus has become the receptacle for a number of species varying widely from the type. In fact, we may truly say that the distinguishing character (if his *italics* are to be relied upon) is the exception instead of the rule. Finding that neither Scudder nor Saussure had allowed themselves to be trammeled by this character, I have concluded to follow them. The subdivisions given above are after Saussure, the latter being in direct opposition to the leading character before alluded to. But, notwithstanding these strictures, I admit there is a marked group for which Fischer evidently intended this genus, the similarity being easily detected by the eye.]

St. obionus, nov. sp.—Female: Head somewhat narrow, face sub-vertical; vertex slightly deflexed, rounded in front, margins elevated, a slight median line; frontal costa obtuse, convex above, with a very slight depression at the ocellus; pronotum sub-truncate in front, posterior extremity obtuse-angled; tricarinate; median carina slightly elevated, entire; lateral carinæ converging before the middle, expanding posteriorly, slightly arcuate in this part; cross incisions indistinct, and all on the anterior half; anal appendages of moderate length; elytra and wings a little longer than the abdomen.

Color (siccus): Testaceous brown, varied with ashy green. Face greenish, varied with light and dark shades; upper portion of the cheeks and cranium brown; a very narrow yellow line running from the eye to the lateral carina of the pronotum. Pronotum testaceous, the anterior lobes being darkest; sides brown; posterior lobe an ashy green, with a dusky median stripe. Elytra pale reddish brown, translucent at the apex; fuscus spots along the middle field and lower border. Venter and pectus dull yellow.

Male: Differs from the female only in size; in the face being more rounded; the upper portions of the head and pronotum being darker; and the spots on the inside of the femora not so dark.

Dimensions: Female—length, 1 inch; to tip of the elytra, 1.1 inch; to end of pronotum, .35 inch; antennæ, about the same; femur, .52 inch. Male—length, .65 inch; femur, .40 inch.

Habitat: First seen on the Arkansas in the vicinity of Cañon City; found in abundance on a species of *Obione.*

St. brunneus, nov. sp.—Female: Somewhat similar to *St. propinquans* (Scudd.) in size and appearance, but rather larger. Vertex broad, scarcely expanding in front of the eyes; angle rounded; apex blunt, margins raised; a faint median line visible. Frontal ridge convex, punctate on the margins, expanding below, not depressed at the ocellus; seen from the side arcuate. Pronotum sub-truncate in front, posterior angle rounded; slightly convergent in the middle; the three carinæ about equally prominent; the three transverse incisions visible on the dorsum; 3 is situated about the middle and is the only one that cuts the median carina. Elytra narrow, about the length of the abdomen; wings about the same length. Posterior femora just the length of the abdomen. Prosternum transversely convex in front; the posterior part slightly excavated in the middle. The superior anal corniculi covered by the hood-like extension of the last abdominal segment; lower pair rather short and slender. Antennæ reach the tip of the pronotum.

Color (siccus): Reddish brown. The vertex and the face bright reddish brown, bordered each side by a yellow stripe which descends in front of the eyes; parts of the mouth yellow; cranium brown, palest in the middle; a narrow yellow line runs from the eye to the lateral carina of the pronotum. Pronotum brown. Wings hyaline, the nerves of the apical portion dark. Femora on the disk testaceous; beneath yellow; inside crossed by two black bands. Tibiæ surrounded by an indistinct yellow ring below the knee; rest a dull yellow (probably blue when alive.) Venter and pectus dull yellow.

Male: Differs only in size and as follows: the face more arcuate; the upper portions of the head and pronotum darker; inside of the femora not so dark.

Dimensions: Female—length, 1 inch; to tip of the elytra, 1.10 inch; to end of pronotum, .35 inch; antennæ, .35 inch; femur, .52; inch. Male—length, .65 inch; femur, .40 inch.

Habitat: Found with preceding; and probably in Eastern Wyoming.

St. quadri-maculatus, nov. sp.—A little smaller than *St. obionus*, similar in shape. Occiput convex, ascending; vertex of moderate width, not expanded in front of the eyes, front margins raised, meeting in a blunt right-angle; face slightly arcuate, deflexed below; frontal costa prominent, flat, not sulcate; margins parallel, punctate, slightly depressed at the ocellus, reaching the clypeus; lateral carinæ distinct and arcurate, reaching the lower angles. Pronotum short, truncate in front, angle behind, tricarinate; median carina slightly elevated; the lateral carinæ more obtuse, convergent a little in front of the middle, forming an entering obtuse angle; divergent anteriorly and posteriorly; cross incision 3 sinuate, cutting all the carinæ, and situated about the middle; incisions 1 and 2 represented on the dorsum by cross rows of punctures. Elytra narrow, and shorter than the abdomen. Posterior femora not passing the abdomen.

Color (siccus): Yellow with brownish spots and stripes. Face yellow; cheeks yellow and fuscus; a narrow fuscus stripe along the cranium; a broad stripe of the same reaching from each eye to the pronotum. Pronotum with alternating dashes of yellow and brown; lateral carinæ yellow; corners of the posterior lobe brown; sides darkest above, yellow below. Elytra pale reddish brown, fading toward the apex, with four brown spots in a row along the middle field, and a little dash of the same near the base. Wings hyaline; nerves mostly white. Abdomen with rings of yellow and brown. Disk and two spots on the upper carina of the posterior femur reddish-brown. Antennæ yellow, darkest at the tips. Under surface pale yellow.

Dimensions: Female, length .88 inch; to tip of the elytra, .75 inch; femur, .50 inch.

Habitat: Southern Colorado and, I think, Eastern Wyoming.

[NOTE.—The living insect is a pale pea-green where the dry is yellow. This and all other species were placed in alcohol before being dried.]

Variety: *a*. Face nearly vertical; frontal costa more prominent and somewhat sulcate; lateral carinæ not so much bent or so divergent; cranium not quite so convex. Lateral carinæ of the pronotum less constricted. The yellow spaces broader and paler; the brown more restricted. This may prove to be a distinct species, but the general appearance is so much the same that I have preferred describing the latter as a variety until more specimens can be obtained. Females only seen.

REMARKS ON THE *CALOPTENUS SPRETUS*.

The following additional facts in regard to this destructive species have been obtained since the publication of the report of last year. I would remark, first, that a pretty full account of the incursions of this insect into the Mississippi Valley has been published in the American Entomologist by the lamented Walsh, who, after a thorough examination of all the data he could obtain, comes to the following conclusion, which I quote in his own words:

> The above facts, and others which it would be tedious to particularize, sufficiently show that the Hateful Grasshopper, when suddenly transferred from its native Alpine home in the Rocky Mountains, some eight thousand feet above the level of the sea, to the warm regions of the valley of the Mississippi, less than a thousand feet above the sea level, gradually becomes diseased and barren, and loses, more or less, its natural appetites and instincts. Why we do not observe the same phenomena in the case of the Colorado potato bug, which was originally a denizen of the same cold Alpine country, is not difficult to explain. The former insect reaches the Mississippi lowlands at one sudden flight, and in one season; it has therefore no opportunity to become gradually acclimatized and inured to the new conditions of life under which it is called upon to exist. Consequently, it becomes diseased and barren, and finally perishes. The latter insect, on the other hand, has reached the Mississippi lowlands only by slow and gradual approaches, breeding at every way-station on the road, and thus becoming, generation after generation, more and more acclimatized to a higher temperature, as indicated by the thermometer, and to a greater atmospheric pressure, as indicated by the barometer. Consequently, it may now be considered as a permanently acclimatized resident of our great western valley; though even here it thrives much better,

and extends eastward much faster in a cold northerly than in a warm southerly latitude. We have traced back the history of this insect as far as the year 1820; and in all these forty-eight years, although no less than seven invasions of the country to the east of the Rocky Mountains have taken place, namely, in 1820, 1856, 1857, 1864, 1866, 1867, and 1868, it has never yet got within one hundred and twelve miles of the Mississippi River; and there is no reason to suppose it will ever do so for the future. There must necessarily be some limit or other to the powers of flight of this insect. It would be absurd, for example, to suppose that it could fly, in one season, as far eastward as England or France, or even as far as the Atlantic Ocean. Consequently, as it can be proved by historical records, that it has never, within the last half century, reached within one hundred and twelve miles of the Mississippi, the fair and reasonable inference is that it never will do so in the future.

His views in regard to the hatching grounds or nativity of this insect are strongly contested by William N. Byers, esquire, of Denver, who has given the subject considerable attention. While Mr. Walsh believes the mountain cañons are the points from which they issue, (with which I at first agreed,) Mr. Byers, on the contrary, thinks they come from the plains west of the Rocky Mountains. I will hereafter give my present opinion, my first view having been somewhat modified by subsequent investigation. I have received from Mr. Byers a full statement of his observations in regard to the history and habits of this insect, from which I make the following quotations:

They generally enter Colorado from some point between north and west, usually about north 30° west. The most destructive flight we ever had here was in 1864. Early in the season we heard of great swarms of grasshoppers hatching out upon the plains of Montana, in the valleys of the Three Forks of the Missouri River, and along the Yellowstone. Later we heard of their progress south and east. In August I was with Professor Parry (now botanist of the Department of Agriculture) and Velie in an attempt to ascend Long's Peak. On the 21st we returned to the plains at the mouth of St. Vrain's Cañon, about fifty miles north of Denver. A man came up the valley, in the evening, to where we stopped, and reported the grasshoppers entering the valley from the north. The next morning, August 22d, I rode down the valley and found portions of the corn fields and grass blackened by their numbers. About five days after, August 27th, the swarm reached Denver, darkening the sky and often covering the streets. They devoured corn, tomatoes, potato vines, onions, &c., almost entirely, and within the space of three to five days. The column moved on, say ten miles per day, and left the (then) settled portions of Colorado within the valley or basin of the Arkansas. We heard no more of them. But myriads remained here, or continued arriving from the northwest, and deposited their eggs in plowed fields and upon rolling, sandy, and gravelly land, where the sod was unbroken. In September and October most of them died. The first swarm devoured all that was green, but Colorado's green crops in August are of small value compared with those harvested in July and up to August 10th. In March following the eggs deposited by them began hatching, first upon sandy, and gravelly hillsides, facing the sun, and later in plowed fields and in colder soils, the outcoming brood reaching too late in May. In walking over the ground the young swarm rose about the feet like a gray mist or dust, the little creatures hopping away like fleas. Where numerous they literally devoured every green thing. If a wheat field (in which none were hatched) was attacked they moved across it, or from the circumference to the center, with the regularity and the effect of advancing flames.

The flights of 1864 destroyed corn and other late crops; the young of 1865 ate up wheat and other small grains. The comparative damage was probably as one to four, the young brood being far the worst, simply because their opportunity was greatest. Generally they move leisurely; their direction influenced largely by the direction of the wind. In fact I attribute mainly their general course to the prevailing winds which come during that portion of the season when they fly most, almost invariably from the northwest. Along toward noon, in bright, warm days, they rise by circular flights, each seeming to act individually, to a considerable height, and then sail away, with tolerable regularity, in one general direction. If there is no wind, many of them continue whirling about in the air, like bees swarming, but, away beyond, myriads can be seen moving across the sun toward the southeast, looking like snow-flakes. If there is a change in the atmosphere, such as the approach of a thunder-storm, or gale of wind, they come down precipitately, seeming to fold their wings and fall by the force of gravity, thousands being killed by the fall, if it is upon stone, or other hard surface. If not interrupted by such causes they descend during the afternoon.

The swarm of August, 1864, and the brood of April and May, 1865, are the only *general* visitations that have scourged Colorado. Similar ones, both flights and broods, have visited portions of the Territory each year since, but generally confined to particular localities or narrow belts.

The swarms that invaded Kansas and portions of Western Iowa in 1867 were traced from their hatching grounds in Western Dakota and Montana, along the east flank of the Rocky Mountains, and in the valleys and plains of the Black Hills, and between them and the main Rocky Mountain range.

The Hateful Grasshopper reaches perfection *only* in a hot dry atmosphere. The greater the heat of air and earth, the brighter the sun, the dryer everything, the more it flourishes. The egg will hatch at a low temperature; cold will probably not destroy it; individual insects will endure a wonderful degree of cold, some living through the entire winter here; but under such circumstances I do not believe that the young will become a perfect insect, capable of perpetuating its species. Heavy dews, frequent showers with prevailing cloudy weather and humid atmosphere are very unfavorable to their growth. Hence I argue that there is no danger of their ever becoming a general or permanent scourge in the United States. The exceptional seasons, like that of 1867, when the season has favored their early development, and prevailing westerly winds carry them steadily and rapidly on their journey, they may invade some of the States of the Mississippi Valley. Their eggs deposited there may even hatch, but I think the product will be a feeble and comparatively harmless generation, from which none will follow.

In 1852 I first observed the insect in question in the vally of the south fork of the Columbia River, not far from Fort Hall. A swarm lasting two or three days passed over from about W. S. W., moving with the wind, at times darkening the sun, covering horses, cattle, and wagons, against which they were driven. The Digger and Snake Indians were gathering them for food. In 1865, when they hatched here, upon attaining about half their full size, they were attacked by a fly, which, stinging them in the back between the root of the wings, deposited one or more eggs, which produced a large white maggot. The worm subsisted upon the grasshopper, finally causing its death, when it cut its way out and entered the earth. In this way probably half were destroyed, often covering the ground and filling the furrows in plowed fields with their carcases. The remainder took to flight, moving southeast, when their wings were sufficiently developed, and we lost trace of them on the great Plains. In the same year, about the last of August, I was in the valley of South Boulder Creek, close up to the Snowy Range, and found the young grasshoppers very numerous, varying in size from those just hatched to one-third grown. I know that winter caught and killed them before they were able to fly out of the valley, or old enough to produce eggs.

In 1867 I observedthe same thing in the valleys west of the Snowy Range. Late in that year the Middle Park was also invaded by full-grown grasshoppers that came from the northwest. They deposited eggs in favorable ground. In 1868 those eggs began hatching in the lowest and warmest portions of the Park in June, increasing in July, and continuing through August and into September in the higher portions of the Park, up toward its rim, where snow and frost continue later in the spring and summer. The *first hatched* moved from their native place up the Park eastward, but never got out of it. The later broods never left their hatching ground. All were destroyed by the fall snows. From the middle to the 25th of August, 1868, I was upon and near the Snowy Range east of Middle Park, and on Long's Peak. There was a large, daily flight of full-grown grasshoppers, from about W. N. W., reaching, apparently, to the highest limit of vision when on the highest peaks. Daily showers prevailed of rain, snow and hail, usually from 12 m. to 3 p.m., and most of the flying insects were beaten down by them, when they became so chilled and benumbed that they never rose again. The snow-fields in many places were literally covered with the dead and dying. Bears were very plentiful feeding and fattening upon them. Hundreds, yes, thousands of bushels might have been shoveled up from the hard snow.

I know that they did not come from the adjacent Middle Park, because those bred there had not then attained their full growth, and never did, as before stated. The migrating swarms, therefore, must have come from beyond—from the Green River basin; or, as I think, from the wide, hot, dry plains of Utah.

These notes by Mr. Byers contain so many important facts in respect to the history of this species, that I have thought it best to make very full quotations from them, that they may be on record for future examination. During the expedition of the present year, while traveling up the North Platte, between Fort Fetterman and Red Buttes, (August 20–23), we observed vast nnmbers of this species. They were not on the wing, having to all appearance ended their flight, and were now pairing, doubtless intending to deposit their eggs there. Frémont encountered a similar swarm in passing over this part of the North Platte Valley. He remarks, "This insect has been so numerous since leaving Fort Laramie that the ground seemed alive with them; and in walking a little moving cloud preceded our footsteps." They had probably ceased their flight, and were preparing to deposit their eggs. By reference to my present report on the agriculture of this section it will be seen that here there appears to be an almost constant current of air sweeping down the Platte Valley from the west. When we reached South Pass City I learned from Major Baldwin that about the first of the month (August) a large swarm had crossed over the pass from the west, moving eastward, and that they had not gone to Wind River Valley. I am satisfied that they did not go upon the Laramie Plains, as I visited that section twice during the season. Nor did we meet with any swarms during our passage up the Sweetwater; we may, therefore, reasonably infer that those we saw on the North Platte were the same that crossed the mountains at South Pass. From whence did they come? As we heard nothing of them during our passage down Big Sandy along the stage road, I infer that they must have come from the northwest; but what distance I have no means of ascertaining. As heretofore stated, they have been very destructive in Utah for the past three years, not only injuring very materially the growing crops, but eating the leaves from the fruit trees to such an extent as to injure the fruit. From Dr. A. T. McDonald, of Provo City, I learned the following particulars in regard to the incursions of this insect into the Territory. That the prevailing cold and winter storms are from the northwest, but that the grasshoppers seldom come from that direction. On the contrary, they generally came from the northeast through the cañons, being brought in by the local currents which sweep through these mountain openings, and that they generally pass off in a southwest direction, though the swarms that come in often remain and deposit their eggs, from which another brood arises in the spring. Sometimes, after a swarm has departed to the southwest, the wind changes, and they are driven back to be swallowed up in the lakes, or perish in the valley. The time of coming varies from the middle of May to the middle of August. The eggs that are deposited here usually hatch out in April and May. The growing crops receive their greatest injury from the young, which are hatched in the valley. The usual method of fighting these young gormands is to drive them into the irrigating ditches, where they are drowned in the water. When they are a little older they are often checked by scattering straw along the edge of the ditches, and driving them into it early in the morning, and then firing it; those which are not destroyed by the fire being caught in the water of the ditch and drowned. But these methods of combating them are practicable only when they are in the larvæ and pupa states.

Dr. McDonald says that in Utah, at least, the females deposit their eggs in the ground in sacks—a fact heretofore noticed and published—on the gravelly elevated plateaus, or foot-hills. And from my observations this season I am inclined to agree with him in the opinion that these elevated table lands, which are composed of coarse sand and gravel, and but slightly covered with vegetation, are the principal hatching grounds of the migratory swarms. The local broods are to be found all over the Rocky Mountain region, from Raton Mountains as far north as I have been, and as far west, at least, as Salt Lake Valley. These are found hatching out in the grassy valleys and broad plains of the lower lands, and up the mountain cañons almost to the snow limits. And these broods appear to have little or no connection with the migrating broods; but the solution of these questions will require more extended observations by those who can distinguish the species.

PART IV.

SPECIAL REPORTS.

I.—PRELIMINARY PALEONTOLOGICAL REPORT,

CONSISTING OF

LISTS OF FOSSILS, WITH DESCRIPTIONS OF SOME NEW TYPES, ETC.

By F. B. Meek.

GENERAL REMARKS.*

The few Silurian fossils enumerated in the following list appear, judging from their affinities, to belong to a low horizon in that series or system of rocks. *Ophileta complanata*, as is well known, occurs in the calciferous group of the Lower Silurian in New York. The specimens in the collection referred to this shell are smaller than the usual size of Vanuxem's species, and may possibly belong to a distinct representative form, though they seem to agree in all respects, excepting in size, with *O. complanata.* An associated sub-discoid shell, belonging apparently to the genus *Raphistoma*, is also nearly allied to a species found along with *O. complanata* in rocks of about the age of the calciferous along Lake Pepin in Minnesota and Wisconsin. Another little gasteropod, however, found associated with those mentioned above, and for which I have proposed the name *Bucanella nana*, is not only congeneric with, but even specifically allied to one found in the Medina sandstone, and some of the higher rocks in New York, though it is nevertheless specifically distinct from the New York form. So far as these few fossils warrant the expression of an opinion respecting the age of the rock from which they were obtained, I should be inclined to place it nearly on a parallel with the calciferous division of the Lower Silurian.

The rock from which the single *Orthis* was obtained at Colorado City is probably also Lower Silurian, as this shell belongs to a section of the genus found in rocks of that age, and is unlike any carboniferous or Devonian form known to me.

In regard to the carboniferous species mentioned in the following list, I have elsewhere remarked that although some of them "are forms known to be common to the lower carboniferous and the coal measures of the Western States, they are *all*, with one or two exceptions, so far as they have been identified, found in the coal measures of Illinois, Iowa, Kansas, and Nebraska, while *not a single one of them* is identical with any of the species peculiar to the carboniferous limestone series below the horizon of the millstone grit in the Western States, though about fourteen of them are peculiar to the coal measures there."†

From these facts it would seem that if the lower carboniferous limestones of the Mississippi Valley are represented at the localities from which these collections were obtained, they probably contain few fossils, and that the principal fossiliferous carboniferous strata there belong to the horizon of the coal measures, as developed farther eastward. We

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* I am under obligations to Professor Henry for the usual facilities at the Smithsonian Institution, while preparing this paper.

† Proceed. Am. Philosoph. Soc., Phila., XI, p. 428, 1870.

have reason to believe that there are, however, in the region of the Great Salt Lake, beds representing some of the higher members of the lower carboniferous series of the Mississippi Valley. Colonel Simpson brought from there, in a dark, very hard limestone matrix, specimens of one of those curious, screw-shaped *Polyzoa*, known by the generic name *Archimedes*, so common in the lower carboniferous limestones of the Western States, but unknown in the coal measures. Some of the corals brought by Colonel Simpson and others are also unlike any of those known in the coal measures of the Mississippi Valley, and more nearly allied to forms found in the upper members of the lower carboniferous limestone series in the States east of the Rocky Mountains.

Among all of the carboniferous fossils yet brought from any part of the Rocky Mountains, as well as from localities west of there, I have never seen a single species indicating the existence there of any representative of the Burlington limestone, which, with its great profusion of beautiful crinoids, forms so marked a horizon in the carboniferous rocks as developed in some of the States farther eastward. This, however, is just what we might expect, since the Burlington limestone, even in the States alluded to, is comparatively limited in its geographical range, and evidently owes its origin to local physical conditions; while the Chester, St. Louis, and Keokuk limestones have a much wider geographical range in the Mississippi Valley, and hence would be more apt to be represented at these distant western localities.

Judging from the few fossils yet brought from the far West that belong to the lower carboniferous, the evidence seems to favor the conclusion that the rocks from which they were collected rather represent the Chester and St. Louis beds than any of the older divisions. It is not improbable, however, that when the whole series of carboniferous deposits in the Rocky Mountains can be thoroughly worked out in detail, there may be found subdivisions there that have no representatives in the Mississippi Valley, as we have reason to believe several members of the series, as made out in the latter districts, may be wanting farther westward. So far as yet known we have no reason to believe, from any paleontological evidence, that the important oldest member of the carboniferous, known in Ohio as the Waverly group or series, occurs in the Rocky Mountain region.

The small collection of fossils I have placed in a separate list, under the heading "Permo-carboniferous," are contained in a brittle, whitish, cherty matrix from Box Elder Station, on Platte River. Although without exception, so far as they can be identified, forms that have an extensive range in the coal measures of the Western States—most of them even extending into the middle and lower coal measures, and one even into the Chester limestone*—these fossils, when viewed together *as a group*, point to a higher position in the series than those that precede them in the following lists. Indeed, there are probably few European geologists unacquainted with the range of these forms in the carboniferous rocks of this country, that would hesitate to refer them to the Permian. The genera *Pseudo-monotis* (*Monotis* of some, not of Bronn) and *Bakevellia* are generally regarded in Europe as characteristic of the Permian, while the *Schizodus*, *Myalina* and *Pleurophorus*, particularly the former two, are specifically closely allied to foreign Permian types. The fact, too, that we find among the specimens from this chert but one species of the *Brachiopoda* (*Hemipronites crassus*) so very com-

* I have recently identified *Hemipronites crassus*, from specimens showing both the internal and external characters, among some collections sent to me from Professor Stevenson from the Chester limestone of West Virginia.

mon in our western coal measures, and scarcely any of the coal-measure *Gasteropoda*, and none of the *Polyzoa*, *Foraminifera*, corals or fish remains, when viewed in connection with the affinities of the forms mentioned, certainly imparts quite a Permian aspect to this little group of fossils.

On the other hand, when we bear in mind the fact above stated, that *all* of the species, so far as they can be identified, are certainly known to range far down into the unquestionable coal-measures of the western States, while we here also find associated with them a *Phillipsia*, a genus entirely unknown in the Permian of Europe, and even belonging to an order or sub-order of Crustacea, not certainly known to have existed after the close of the Carboniferous epoch, we at once see the necessity for caution in referring this rock to the Permian, on such evidence.

Every one familiar with the organic remains of the coal-measures of the Mississippi Valley, is aware of the fact that we not unfrequently meet with thin local beds and seams there, containing precisely such a group of fossils, and yet overlaid, where there is not the slightest disturbance of the strata, by hundreds of feet of unmistakable coal-measures, filled with their characteristic plants, *Foraminifera*, *Brachiopoda*, *Lamellibranchiata*, *Gasteropoda*, Trilobites, fish remains, &c. Hence it is more probable that the association of these ten or twelve fossils in this bed of chert, and the absence, so far as known, of the other forms mentioned, resulted from some peculiar local physical conditions *before*, rather than at or *after* the close of the carboniferous period. The probability is, that this bed belongs to the same horizon as the rocks in Kansas, to which we have applied the name Permo-carboniferous, though it may be even somewhat older.

The few forms placed in the list under the heading "Jurassic species," nearly all came from the same horizon, and some of them from the same localities, as those we have figured and described in the paleontology of the Upper Missouri, and there referred to the Jura. Although the species known from these beds are amply sufficient to prove them to be of Jurassic age, they scarcely warrant, or, at any rate, have not yet been sufficiently compared with European Jurassic species to justify a positive opinion in regard to their precise horizon in that great series of rocks, though they appear to occupy a rather low position in the same, judging from their affinities. The single *Ammonite* from between Sacramento and Summit Station, described by Mr. Gabb, under the name *A. Nevadensis*, probably came from the horizon of some part of the Lias.

The cretaceous species enumerated in the list belong to horizons representing all of the subdivisions of the cretaceous series as made out in the Upper Missouri country, and serve to illustrate, to some extent, the geographical extension of these several rocks or groups, southward and westward from the original typical localities. The numbers 1, 2, 3, 4, and 5, along the right-hand margin of the list, opposite the localities, show to which member of the Upper Missouri cretaceous each species belongs—the subdivisions of the Upper Missouri cretaceous having been severally named and numbered from below upward, as follows: No. 1, Dakota Group; No. 2, Fort Benton Group; No. 3, Niobrara Division; No. 4, Fort Pierre Group, and No. 5, Fox Hills Beds; the names being derived from localities where the several formations are well developed.

The specimens from twelve miles southwest of Salina, Kansas, came from a brown ferruginous sandstone belonging to the horizon of the Dakota Group, or oldest division of the Upper Missour cretaceous series.

For these we are under many obligations to Professor B. F. Mudge, of the Kansas Agricultural College, at Manhattan.* They are especially interesting, because we have hitherto known only a few of the *Mollusca* of this horizon, though the remains of many species of forest trees had been obtained from this rock, both on the Missouri and in the interior of Kansas. The shells discovered by Professor Mudge are marine types, with probably the exception of two species of *Corbicula;* while on the Missouri we have obtained from this rock only a few marine types, such as *Mactra* and *Axinæa*, associated with *Cyrena*, *Unio*, and *Pharella*.

It is proper to remark here that, although we usually speak of this Dakota Group or division as belonging to the *earlier* or *lower* cretaceous of the Upper Missouri country, we do not thereby mean that it belongs to the *lower* part of the cretaceous *system*, as understood in Europe; but simply that it is the oldest member of the series yet certainly known in the Upper Missouri country. It is probably not older than the lower or gray chalk of British geologists, as we have elsewhere explained.

The specimens from near Fort Bridger and Medicine Bow River, Wyoming, as well as from six miles west of Cañon Station and Dodson's Ranch, show that the Fort Benton Group or division of the Upper Missouri cretaceous occurs at those localities. Among the specimens from between Hardscrabble and St. Charles, from Fort Bascom, Medicine Bow River, and Colorado City, there are characteristic forms of the Niobrara Division; and from the mouth of Deer Creek, Wyoming, valley of Fountain Creek, and Box Elder Creek, Colorado, there are Fort Pierre forms. The Fox Hills beds are also shown to be represented at Fountain Creek, and Colorado City, Colorado.

Some of the specimens from near Bear River, and at Coalville, Utah, from a light-colored sandstone, containing beds of a good quality of brown coal, appear to belong to a member of the cretaceous series not corresponding to any of those named in the Upper Missouri country; though it is, as I believe, represented by a similar sandstone under the oldest estuary tertiary beds at the mouth of the Judith River, on the Upper Missouri. In 1860 Colonel Simpson brought from this rock, on Sulphur Creek, a small tributary of Bear River, in Utah, some casts of *Inoceramus*, and other fossils; and in some remarks on Colonel Simpson's collection, published by the writer, in connection with Mr. Henry Engelmann, the geologist of Colonel Simpson's survey,* we referred this formation to the cretaceous. The collections that have since been brought in from it, in Utah, by Mr. King's and Dr. Hayden's surveys, confirm the conclusion that it belongs to the cretaceous, as they contain, among other things, species of *Inoceramus*, *Anchura*, *and Gyrodes*—genera that seem not to have survived the close of the cretaceous period. In addition to this, there is among Dr. Hayden's collections from this rock, at Coalville, a *Turritella* that I cannot distinguish by the figure and description, even specifically, from *T. Martinezensis*, described by Mr. Gabb, from one of the upper beds in California referred to the cretaceous. A *Modiola* from the same horizon also appears to be specifically identical with *M. Pedernalis*, of Roemer, from the cretaceous of Texas. Dr. Hayden also has, from a little above the coal beds at Coalville, specimens of oyster that seem much like *O. Idriaensis* and *O. Brewerii*, of Gabb, from the upper beds of the California cretaceous. As no other fossils were found directly associated with these oysters,

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*I have prepared a quarto plate fully illustrating these fossils, to be published in the Paleontology of the Upper Missouri.

* See Proc. Acad. Nat. Sci., Phila., 1860.

however, nor any strictly marine forms above them, it is possible that they may belong to the lower tertiary.

From the affinities of some of these fossils to forms found in the latest of the beds referred in California to the cretaceous, and the intimate relations of these marine coal-bearing strata of Utah to the oldest tertiary of the same region, and the apparent occurrence of equivalent beds bearing the same relations to the oldest brackish-water tertiary beds at the mouth of Judith River on the Upper Missouri,* I am inclined to believe that these Coalville beds occupy a higher horizon in the cretaceous than even the Fox Hills beds of the Upper Missouri cretaceous series; or, in other words, that they belong to the closing or latest member of the cretaceous.

All of the explorers of this region concur in the statement that the above-mentioned cretaceous beds are intimately related to the succeeding brackish-water deposits that appear to belong to the oldest tertiary; the two formations, wherever they occur together, being conformable and without any intermediate beds, so that the one seems to shade into the other, without any abrupt or sharply-defined line of separation; the change being mainly indicated by a gradual transition from beds containing cretaceous types of only marine origin, to those with brackish and fresh water types, apparently most nearly allied to early eocene species of the Old World.

So far as yet known, there would appear to be no strictly marine tertiary deposits in all this interior region of the continent; even the lower parts of the surface here having been apparently gradually elevated above the sea level at, or very near, the close of the cretaceous period. For the same reason all of the beds hitherto referred with confidence to the cretaceous are of undoubted marine origin, as they contain only marine types.

These cretaceous gulfs or seas, however, evidently did not occupy the whole country here, as we know from the absence of cretaceous deposits throughout what were doubtless wide areas, or possibly, in some cases, smaller islands of dry land at that time. As the whole surface was gradually elevated, however, even the lowest portions rose finally to near the tide level, thus, probably, leaving large inlets and estuaries of brackish waters that subsequently became so far isolated by the continued elevation, and from sedimentary deposits, as to prevent the influx of the tides and form fresh-water lakes, in which the later fresh-water and terrestrial types of fossils only were deposited.

That this change from marine to brackish-water conditions was *exactly* contemporaneous with the close of the cretaceous epoch, and the introduction of the tertiary in Europe, is not certain; nor is it necessary that this should have been the case to constitute the older rock cretaceous and the later tertiary, because in the use of these terms we have reference rather to the *order of succession* of certain great physical changes, affecting life in distantly-separated parts of the earth, than to the *exact* time of the occurrence of these changes.

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* Associated with the estuary beds at the mouth of Judith River, on the Upper Missouri, there is a yellowish arenaceous rock, agreeing exactly in its lithological characters with the coal-bearing strata on Bear River, in Utah, and containing an oyster apparently belonging to the same species as one found in the rock mentioned at the latter locality. All of the strata at this Judith River locality are upheaved, and more or less mingled together, and I have long suspected that some vertebrate remains found there by Dr. Hayden, and supposed by Dr. Leidy to be cretaceous types, belong rather to the sandstone, that appears to be an equivalent of the Bear River coal strata of Utah, than to the estuary beds. It is even possible that equivalent beds at other localities in the Upper Missouri country may have been, from the absence of characteristic fossils, included along with the tertiary.

* The oldest beds in the Bear River country of Utah and Wyoming, properly belonging to the tertiary, and, as above stated, so intimately related to the latest cretaceous, contain species of *Corbula*, *Cyrena*, (*Corbicula*), perhaps *Ostrea* and a univalve related to *Melampus*, directly associated with several species of *Goniobasis*, two of *Unio*, one or two of *Melantho*, several species of *Viviparus*, one of *Tiara*, &c., showing clearly that these strata were deposited in brackish waters.† These shells also exist in great numbers, and are preserved in a condition showing that they could not have been transported far by currents, but that they must have lived and died at least near where we now find them.

All paleontologists are aware of the fact that the remains of fresh and brackish-water shells do not generally present such well-marked peculiarities of form, ornamentation, &c., in beds of different ages, as we see in marine types, so that they cannot always be relied upon with the same degree of confidence in identifying strata that we place in marine forms; some of those from oldest cretaceous being, for instance, very similar to existing species. So far as I have been able to compare the species from this formation with described forms from other parts of the world, they generally agree most nearly with lower eocene types; the Corbiculas and *Tiara* being very similar to forms found in the lower lignites of the Paris basin, and at the mouth of the Rhone in France. At the same time it is worthy of note, that most of these shells are quite unlike any of the known existing North American species, and one of them (*Tiara humerosa*) belongs even to a genus entirely unknown among the existing Melanians of the American continent, though found inhabiting the streams of Madagascar, the Fejee Islands, &c. One of the Uniones (*U. belliplicatus*) resembles in its ornamentation some of the South American species and the genus *Castalia*, much more nearly than it does any of the recent North American species, although having the form and hinge of a true *Unio;* and another abundant bivalve, found in the same associtiaon (*Corbula Anisothyris pyriformis*) seems to be allied in some respects to a peculiar group recently described from a pliocene or miocene formation on the Upper Amazon of South America, by Mr. Gabb, under the name *Pachydon*, and afterward renamed *Anisothyris* by Mr. Conrad, because the name *Pachyodon* had been previously used for another genus.

This last-mentioned shell (*Corbula pyriformis*) was referred by me, provisionally, to *Azara*, because it occurs in the sams beds with fresh and brackish-water forms, and has the general aspect of some species of *Corbula*, which group is believed by some good authorities on conchology to include *Azara* as a sub-genus; while none of our specimens showed the hinge. Among some of the latter collections, however, I found specimens by which I was enabled with considerable difficulty to succeed in working out the hinge, and found that it does not agree with that of *Azara*, but apparently conforms almost exactly with that of *Corbula*, with probably the exception of some regular furrows on the tooth of the right valve. From its brackish-water habits, however, and its general similarity of form to *Anisothyris* or (*Pachydon*) *erectus*, Conrad, I referred it, in manuscript, to *Anisothyris*, placing that group as a sub-genus under *Corbula*. Soon after I mentioned, in a letter to my friend Mr. Conrad, that I had discovered that this shell does not possess the hinge of *Azara*, and that I had referred it to *Anisothyris*.

* These remarks from this paragraph to the end of the first paragraph ending on page 295, inclusive, were extracted and printed in pamphlet form, excepting the foot notes, on the 18th February, 1871.

† The conditions, however, might have been such that the saltness of these estuaries was, *at first*, very little diluted by the streams that brought from the adjacent shores the fresh-water types.

Subsequently I received a note from Mr. Conrad, informing me that he had proposed, in manuscript, a sub-genus, *Anisorhynchus*, for this species. If this separation from *Corbula* is necessary, however, on account of the habits of the species, I would think it should still stand as a sub-genus under that group, or, in other words, that the name of the species should be written *Corbula* (*Anisorhynchus*) *pyriformis*, because it seems to me even doubtful whether *Anisothyris* is more than sub generically distinct from *Corbula;* while the species *C. pyriformis* is still more closely allied to *Corbula* than *Anisothyris* is; in fact, it agrees almost exactly, in its hinge, muscular, and pallial impressions, with *Corbula*, even in the very few characters distinguishing *Anisothyris* from the same, and we have almost nothing left but its Neara-like form, and brackish-water habits, to separate it from *Corbula;* while some marine species, such as *C. alæformis* of Gabb, present almost exactly the same form.

It may be proper to remark in this connection that the South American group *Anisothyris*, or *Pachydon*, is much more nearly allied to *Corbula* proper than was supposed by my friends Mr. Gabb and Mr. Conrad, (although the latter placed it near *Corbula*) since they both thought it had an external ligament, and no internal cartilage. On examining good specimens of six of the South American species sent on by Professor Orton to the Smithsonian Institution, however, I at once satisfied myself that these shells certainly had an internal cartilage in a pit behind the tooth in the right valve, and attached to a process in the left, exactly as in *Corbula*, excepting that the process is more oblique and less flattened than is usual in that genus.*

On mentioning these facts in regard to the presence of an internal cartilage, in a letter to Mr. Conrad, he wrote back that a further examination had satisfied him that I was right in this, and that he now rests the group entirely upon its sub-spiral beaks, a kind of rudimentary posterior lateral tooth in the right valve, and a small accessory scar at the upper end of that of the posterior adductor, together with the brackish-water habits of the species. It should be borne in mind, however, that this faint rudimentary posterior lateral tooth does not exist in all the typical species; while it is obscurely represented in some marine tertiary species of *Corbula;* nor have I been able to find the posterior pedal muscular scar in them all, more clearly defined than in some marine tertiary species of *Corbula*.

Several of the other forms found in these Bear River beds present more marked peculiarities than are to be seen in *Corbula pyriformis*, which may render it desirable to place them under separate sub-generic groups; for instance, that I have described under the name *Corbicula Durkeei*, which is a remarkable trigonal, thick shell, has the posterior dorsal margins of the valves inflected, and the cardinal teeth directed more obliquely backward than we see in the recent species, while its elongated lateral teeth are nearly or quite smooth, instead of being transversely striated. The posterior lateral tooth of its left valve is also mainly formed by the beveling of the inflected margin, instead of standing out as a distinct tooth. In some respects this shell is more like *Verlorita*, from which, however, it differs materially in others.

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* In some interesting remarks, recently published by Mr. Henry Woodward of the British Museum, in the Ann. and Mag., N. A., on the relations of *Anisothyris* to *Corbula* and some allied groups, he mentions as one of the differences, that the latter have the cardinal tooth in the left valve, while in *Anisothyris* it is in the right, and the socket *vice versa*. This, however, is probably due to some typographical error, as there is certainly no difference in the position of the cardinal tooth and socket, or in that of the cartilage process with relation to each other, or to the two valves, between *Corbula* and *Anisothyris;* both having the tooth in the right valve, and the socket and cartilage process in the left.

If it should be thought desirable to make it the type of a distinct sub-genus, it may be called *Corbicula (Veloritina) Durkeei*. In the same way, if the proposed sections of *Unio* should be sustained, the curiously plicated species, described by me under the name *U. belliplicata*, may be called *U. (Loxopleurus) belliplicatus*.†

I have elsewhere proposed, in manuscript, to make my *Melampus priscus* from this formation, the type of a new group, under the name *Rhytophorus priscus*, on account of its peculiar costated surface, smooth outer lip, and single well-developed plait, and another obscure one, on the columella.

Of the species of *Tiara*, already mentioned from this rock, thousands of specimens have been obtained, and yet it is remarkable that not a single one of them shows the lip about the lower part of the aperture unbroken, and entirely free from the matrix. Some of those I have recently seen, however, appear to show a kind of angularity about the base of the aperture not seen in the typical forms of *Tiara*, and some appearance of a peculiar furrow along the outer edge of the base of the columella. If these are not due to accident—and they certainly seem not to be—it may be found that this shell should be regarded as the type of a sub-genus, bearing somewhat similar relations to *Tiara* to those existing between *Goniobasis* and the elongated old world Melanians. If so, it may be called *Tiara (Pyrgulifera) humerosa*.‡

Of course, comparisons of the shells from this formation with those of the tertiary beds of the Atlantic and Pacific slopes, afford no aid whatever in fixing its precise position in the series, because the species from the latter are, almost without exception, marine types. There is less difficulty, however, in drawing parallels between it and the tertiary deposits of the Upper Missouri country, by a comparison of fossils, although the *species* are mainly different, so far as yet known, in these two districts. At least two of the known forms, however, from the Utah and Wyoming beds under consideration, are believed to be specifically identical with species found in the oldest beds referred to the tertiary at the mouth of Judith River on the Upper Missouri, under the name Fort Union Group. These are *Unio priscus* and *Viviparus Conradi*. In addition to this, the fossils at these two localities are in precisely the same state of preservation, and have a more ancient appearance than those of the later deposits of both districts, while they also agree exactly in their mixture of brackish and fresh-water characters. Again, at both localities, these deposits are intimately associated, as already stated, with what appears to be the latest of the cretaceous series; while in

† I have had no opportunity to consult Spix's work in which he proposed the group *Diplodon*, but had supposed from the strongly alate-shell figured by Sowerley as an illustration of the same, that it was founded on a widely distinct type from our Utah shell. From the diagnosis of *Diplodon*, given by H. and A. Adams, however, I am led to think it may possibly include our type, though I cannot believe the North American species ranged by the above-named authors should be placed in the same section with our species.

‡ Since these remarks were in type and issued in pamphlet form, Mr. Conrad kindly sent me a sketch of a specimen of this species at the Philadelphia Academy of Science, showing more of the lip and base of the aperture than I had seen, and expressed the opinion that it is a good genus. Soon after I succeeded in working the matrix from the aperture of a perfect very large specimen, and from this and Mr. Conrad's sketch, the inner lip is seen to be quite thick all the way up, but particularly below, and the narrow base of the aperture sinnous. My specimen also shows that there is a shallow marginal sinus of the outer lip at the termination of the shoulder, while below this it is prominent. It is therefore evident, that with the distinctly turreted spire, shouldered and coronate wheels, as well as the general aspect of *Tiara*, in its thickened inner lip and some other characters, it resembles *Lithasia*, and constitutes a distinct genus from both, in which opinion Mr. Conrad and Professor Gill concur.

both districts they contain lignite, and are succeeded by later tertiary beds of strictly fresh-water origin.

The fossils from the later tertiary deposits of Wyoming and Utah, mentioned in the lists, came from Henry's and Black's Forks of Green River, Church Buttes, Barrel Springs, Fort Bridger, Pacific Springs, and other localities of the same region. They belong to the genera *Unio*, *Sphærium*, *Goniobasis*, *Bythinella*, *Physa*, *Planorbis*, &c., most of which are very numerous in individuals, though there are not many species of any one of these genera. From the entire absence of marine and brackish-water types in these beds, it seems evident that they were deposited in fresh-water lakes, entirely isolated from the influx of tides, in basins that were raised above the level of the sea, in part by the accumulation of sedimentary deposits, and probably in part from the gradual elevation of the whole country. These later beds may be susceptible of subdivision into several subordinate groups, but the fossils yet known show closer relations between the different beds of this series than between any of them and the brackish-water deposits beneath. Indeed, I have not been able to identify a single species from the latter with any of those from the strictly fresh-water beds under consideration, and they are also equally distinct from all of those known from the Upper Missouri country.

From the differences observable between the species found in these fresh-water deposits and the older brackish-water beds of the same region, believed to belong to the eocene, and the superposition of the former, it is reasonable to infer that the later series belongs wholly or mainly to the horizon of the miocene, especially as none of the fossils contained in these beds are certainly known to belong to existing species.

LISTS OF FOSSILS COLLECTED.

SILURIAN SPECIES.

1. *Orthis desmopleura*, Meek[1]; Colorado City.
2. *Meristella* or *Merista* (undetermined species); Crater's Falls.
3. *Ophileta complanata*, var. *nana;* Crater's Falls.
4. *Bucanella nana*, Meek[2]; Crater's Falls.
5. *Raphistoma;* Crater's Falls.
6. *Endoceras* (undetermined species); Crater's Falls.

CARBONIFEROUS SPECIES.

1. *Fusulina cylindrica*, Fischer; Moleen Station.
2. *Syringopora* (undetermined specimen); Moleen Station.
3. *Campophyllum*, like *C. torquium*, Owen; Hot Springs, Salinas Creek, Salt Lake.
4. *Zaphrentis* (?); Head Black Fork Bear River, Utah.
5. *Crinoid columns;* Pecos Church, Mora Creek, and Hot Springs.
6. *Chætetes* (undetermined massive and ramose forms); Moleen Station, Salinas Creek.
7. *Fenestella* and *Polypora;* near Pecos Range, 10 miles south of Kosylowiski, New Mexico, and Mora Station.
8. *Synocladia* (*Septopora*) *Cestriensis*, Prout (sp.); Mora River.
9. *Orthis* (undetermined species); Santa Fé, New Mexico.
10. *Hemipronites crassus*, M. and W.; Santa Fé, New Mexico, Box Elder Cañon, North Platte.
11. *Chonetes* (undetermined species); Santa Fé, New Mexico, Box Elder Cañon.
12. *Productus Nebrascensis*, Owen; Moleen Station, Santa Fé, New Mexico.
13. *Productus punctatus*, Martin, (sp.); Sangre de Christo Pass, Colorado.

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1. I proposed for this species the name *O. Coloradoensis*, in the Proceed. Am. Philosoph. Soc., xi, p. 425, 1870; but as Dr. Shumard had previously used that name for another species of this genus, it becomes necessary to make a change.
2. Proceed. Am. Philosoph. Soc., xi, p. 426, 1870.

14. *Productus semireticulatus*, Martin, (sp.); Sangre de Christo Pass, Colorado, and Pecos Church, Mora City, Weber Mountains, Box Elder, North Platte.
15. *Productus nodosus*, Newberry; Mora Creek, New Mexico, Hot Springs, Salinas Creek, Santa Fé, New Mexico.
16. *Productus Prattenianus*, N.; head Black's Fork, Bear River, Utah.
17. *Productus longispinus*, Sow., *Var. Wabashensis*, N. and P.; Hot Springs, Salinas Creek, Santa Fé, New Mexico.
18. *Productus* (two or more undetermined species); Santa Fé, New Mexico.
19. *Spirifer* (Martinia) like *S. planoconvexus*, Shum.; Moleen Station.
20. *Spirifer cameratus*, Morton; Pecos Church, Mora Creek and River, New Mexico.
21. *Spirifer Rocky-Montani*, Marcou (?); Santa Fé, Mora Creek, New Mexico.
22. *Athyris subtilita*, Hall, (sp.); Santa Fé, Mora Creek, 10 miles south of Kosylowiski; near Pecos, New Mexico, and Sangre de Christo Pass, Colorado.
23. *Aviculopecten* (undetermined species); near Pecos River, New Mexico.
24. *Aviculopecten carbonarius*, Stevens; near Pecos River, New Mexico.
25. *Myalina Swallovi*, McChesney; 10 miles south of Kosylowiski.
26. *Avicula* (undetermined species); 10 miles south of Kosylowiski.
27. *Pleurophorus angulatus*, M. and W.; 10 miles south of Kosylowiski.
28. *Bellerophon* (fragments of large undetermined species); Moleen Station.

PERMO-CARBONIFEROUS. (?)

1. *Fragments of Crinoid columns;* Box Elder Station, Platte River.
2. *Hemipronites crassus*, M. and H.; Box Elder Station, Platte River.
3. *Aviculopecten occidentalis*, Shum.; Box Elder Station, Platte River.
4. *Myalina perattenuata*, M. and H.; Box Elder Station, Platte River.
5. *Pseudomonotis Hawni*, M. and H.; Box Elder Station, Platte River.
6. *Bakevellia* (undetermined species); Box Elder Station, Platte River.
7. *Pinna peracuta*, Shum.; Box Elder Station, Platte River.
8. *Schizodus curtus*, M. and W.; Box Elder Station, Platte River.
9. *Edmondia Aspenwallensis*, M. (New species; see description at end of list.) Box Elder Station, Platte River.
10. *Pleurophorus* (?) (undetermined casts); Box Elder Station, Platte River.
11. *Macrocheilus*, (undetermined species); Box Elder Station, Platte River.
12. *Orthoceras* (?) (small undetermined species); Box Elder Station, Platte River.
13. *Phillipsia* (fragments of an undetermined species); Box Elder Station, Platte River.

JURASSIC SPECIES.

1. *Ostrea* (a very small, undetermined species, with beak truncated); mouth Henry's Fork of Green River, Dakota Teritory.
2. *Camptonectes extenuatus*, M. and H.; mouth Henry Fork of Green River, Dakota Territory.
3. *Camptonectes bellistriatus*, M. and W.; Red Buttes, Green River, Dakota Territory.
4. *Trigonia* (a small, undetermined species of jurassic type); Red Buttes, Green River, Dakota Territory.
5. *Bivalves* (casts of several small, undetermined species); Red Buttes, Green River, Dakota Territory.
6. *Cardinia* (?); Salinas Creek, Hot Springs.
7. *Pholadomya* (mere rude undeterminable casts); Salinas Creek, Hot Springs.
8. *Belemnites densus*, M. and W.; Como.
9. *Ammonites Nevadensis*, Gabb; between Sacramento and Summit Station.

CRETACEOUS SPECIES.

1. *Ostrea congesta*, Conrad; between Hardscrabble and St. Charles. Cret., No. 3.
2. *Ostrea soleniscus*, Meek; near Bear River, associated with coal. Cret., No.—(?)
3. *Ostrea appressa*, Gabb ?[3]; Coalville. No.—(?)
4. *Gryphæa navia*, Conrad; Fort Bascom. Cret., No. 3.
5. *Inoceramus Sagensis*, Owen (?); Fountain Creek, Colorado City, Colorado. Cret., No. 4.
6. *Inoceramus fragilis*, H. and M.; Medicine Bow River. Cret., No. 3.
7. *Inoceramus problematicus*, Schloth, (sp); Fountain Creek, between Hardscrable, Dodson Ranch, and St. Charles. Cret., Nos. 2 and 3.
8. *Inoceramus* (undetermined species); six miles east Como Station, Union Pacific Railroad. Cret., No. 2.
9. *Inoceramus deformis*, Meek[4]; Colorado City. Cret., No. 3.

3. This may be either Mr. Gabb's *O. appressa* or his *O. Idriaensis*, if they are distinct, as there are among the specimens individuals that agree pretty well with both, and yet seem to be only varieties of one species. These and *O. Soleniscus* are found just above a bed of brown coal, and may possibly be lower tertiary, but are more probably upper cretaceous.

4. See Frémont's Report, pl. iv, fig. 2.

10. *Inoceramus* (undetermined species[5]); Cache la Poudre River, near Greeley, Denver and Pacific Railroad. Cret., No. 3.
11. *Inoceramus aultus,* Meek; near Medicine Bow Station, Pacific Railroad. Cret., No. 3.
12, *Cucullæa* (undetermined species); Dodson Ranch. Cret. No. 2.
13. *Modiola Pedernalis,* Roemer; Near Coalville. Cret., (?)
14. *Nuculana* (undetermined species); Near Coalville. Cret., (?)
15. *Pachymya (?) truncata,* Meek, (new species, see description,) (?) 4. Exact localiy unknown.
16. *Crassatellina oblonga,* Meek, (new species, see description); twelve miles southwest of Salina, Kansas, Professor Mudge. Cret. No. 1.
17. *Unio Nebrascensis,* Meek (new species, see description); opposite Sioux City, Dakota County, Nebraska. Cret. No. 1.
18. *Arca (?) parallela,* Meek (new species, see description); twelve miles southwest of Salina, Kansas, Professor Mudge. Cret. No. 1.
19. *Yoldia microdonta,* Meek (new species, see description); twelve miles southwest of Salina, Kansas, Professor Mudge. Cret. No. 1.
20. *Cardium pauperculum,* Meek (new species, see description); near Fort Bridger, Wyoming. Cret. No. 2.
21. *Cardium Kansasensis,* Meek (new species, see description); twelve southwest of Salina, Kansas, Professor Mudge. Cret. No. 1.
22. *Cardium (Protocardia) salinens,* Meek (new species, see description); twelve miles southwest of Salina Kansas, Professor Mudge. Cret. No. 1.
23. *Cyrena (Corbicula?) nucalis,* Meek (new species, see description); twelve miles southwest of Salina, Kansas, Professor Mudge. Cret. No. 1.
24. *Cyrena (Corbicula?) subtrigonalis,* Meek (new species, see description); twelve miles southwest of Salina, Kansas, Professor Mudge. Cret. No. 1.
25. *Mactra (?) Cañonensis,* Meek (new species, see description.)
26. *Tapes Wyomingensis,* Meek (new species, see description); mouth Deer Creek, Wyoming. Cret. No. 4.
27. *Tellina subscitula,* Meek (new species, see description); twelve miles southwest of Salina Kansas, Professor Mudge. Cret. No. 1.
28. *Tellina (?) mactroides,* Meek (new species, see description); twelve miles southwest of Salina, Kansas, Professor Mudge. Cret. No. 1.
29. *Leptosolen Conradi,* Meek (new species, see description); twelve miles southwest of Salina, Kansas, Professor Mudge. Cret No. 1.
30. *Anchura (?)* (undetermined species); Dodson's Ranch.
31. *Turritella Martinezensis,* Gabb (?); Coalville, Utah.
32. *Turritella Kansasensis,* Meek (new species); twelve miles southwest of Salina, Kansas, Professor Mudge. Cret. No. 1.
33. *Anisomyon centrale,* Meek (new species); Valley of Fountain Creek and Box Elder Creek, Colorado. Cret. No. 4.
34. *Pleurotomaria (?)* (undetermined species); near Coalville, Utah.
35. *Turbo Mudgeanus,* Meek (new species); twelve miles southwest of Salina, Kansas, Professor Mudge. Cret. No. 1.
36. *Baculites compressus,* Say; Fountain Creek, Colorado City. Cret. No. 4.
37. *Baculities ovatus,* Say; Fountain Creek, Colorado City, Miser Station, and Como. Cret. No. 4.
38. *Scaphites (Discoscaphites) Conradi,* Morton[6]; Fountain Creek, Colorado City. Cret. No. 5.
39. *Scaphites (Discoscaphites) Cheyennensis,* Owen; Fountain Creek, Colorado City. Cret. No. 5.
40. *Scaphites nodosus,* Owen; Fountain Creek, Colorado. Cret. No. 4.
41. *Scaphites Warrenanus,* M. and H.; Medicine Bow River. Cret. No. 2.
42. *Ammonites* (undetermined, not a typical ammonite.) Fountain Creek, Colorado.

5. This is a rather large, longitudinally oblong or depressed suboval, very gibbous, equivalve species, with a long, straight hinge line, and with posterior side long and subtruncated or more or less obliquely rounded. Its beaks are equal, very gibbous, oblique, depressed, and almost terminal, while its internal casts only show more or less irregular, sometimes obscure, concentric undulations. It seems to be distinct from all of the previously known far-western species, and if new may be called *I. oblongus*.

6. This is the type of a group of Scaphites, for which I have proposed (Proced. Am. Phil., Soc., xi, p. 429) the name *Discoscaphites*, compared with the typical species of Parkinson's genus, such as *S. æqualis*, Sowerby, these shells are seen to differ in having the characteristic extension of the body volutions so very slightly developed that they have often been referred to the genus *Ammonites*. They also differ in having the peripheny, especially in the adult, more or less flattened, and the sides of the volutions occupied by numerous small nodes, arranged in regular revolving rows. The group includes two sections, the first of which (represented by *S. Conradi*) has the volutions so broad and deeply enveloping as to leave only a very small umbilicus, while the second (represented by *S.* [*Disco.*] *Cheyennensis*, Owen, and *Ammonites* [*Disco.*] *Mandanensis*, Morton) has a wider umbilicus, with the body volution very narrow and but little enveloping.

7. This may be regarded as the type of a group of Ammonites, for which I proposed (Proc. Philos. Soc., xi, p. 429) the name *Placentocerus*. Compared with *Ammonites bisulcatus*, Bruguiere (which it seems to me should be regarded as the type of that genus, because it was long back cited alone as the typical form by Lamarck.) This shell will be observed to differ remarkably in several respects, particularly in its broad, profoundly-enveloping volutions, with flattened non-costate sides, and very nar-

43. *Ammonites (Placentocerus) placenta*, DeKay[7]; Fountain Creek, Colorado City. Cret. No. 4.
44. *Ammonites (Pleuroceras?) serrato-carinatus*, Meek 8; Medicine Bow Creek, 2.

TERTIARY SPECIES.

1. *Unio priscus*, M. and H.[9]; Limestone Hill, Bear River City, and Parley's Park, Utah, Gilmore, Wyoming. Eocene.
2. *Unio Washakeei*, Meek (new species, description at end of list); Washakee, Henry's Fork, Green River, and on the latter stream, Wyoming. Eocene.
3. *Unio Haydeni*, Meek; between Grand and Green Rivers, Fort Bridger.
4. *Unio tellinoides*, Hall (?) (sp.)[10]; Barrel Springs, Muddy Creek, Wyoming.
5. *Unio Leanus*, Meek (new species, see end of list); Church Buttes, Henry's Fork, Barrel Springs, and other localities in Wyoming. Miocene.
6. *Unio (Diplodon?) belliplicatus*, Meek; Parley's Park, Utah; Gilmore, Wyoming. Eocene.
7. *Corbicula (Veloritina) Durkeei*, Meek; Bear River City, Parley's Park, Utah, and Gilmore, Wyoming. Eocene.
8. *Cyrena (Corbicula?) fracta*, Meek (new species, see description); Hallville coal mines. Eocene.
9. *Cyrena (Corbicula?) crassatelliformis*, Meek (new species); Hallville coal mines. Eocene.
10. *Sphærium* (undetermined, perhaps 2 species); Elkton, Central Pacific railroad, beyond Salt Lake. Miocene.
11. *Sphærium* (undetermined species); Barrel Springs, Wyoming. Miocene.
12. *Corbula (Anisorhynchus) pyriformis*, Meek; Parley's Park, Limestone Hill, and Bear River City, Utah; Gilmore, Wyoming. Eocene.
Corbula (Anisorhynchus) pyriformis var. consentrica, Meek.
13. *Corbula (Anisorhynchus) Engelmanni*, Meek; Limestone Hill and Sulphur Creek, Utah. Eocene.
14. *Goniobasis Simpsoni*, Meek; Fort Bridger, divide between Muddy and Black Forks. Miocene.
15. *Goniobasis tenera*, Hall? (sp.)[11]; Barrel Springs, Wyoming. Miocene.

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rowly-truncated and flattened, or slightly-concave periphery, small umbilicus, &c.; also in the much more numerous lateral lobes of its septa, which increase in size to the third one inclusive, and thence become gradually and regularly smaller to the umbilicus. It probably includes several cretaceous species.

In the same way, *Ammonites lobatus* of Tuomey may be regarded as the type of another group, differing from *Placentocerus* in having the periphery sharply cuneate all around, and the sinuses or saddles between its numerous lateral lobes (which agree in number and proportional size with those in *Placentocerus*), presenting very curious obtusely-lobed or uniform outlines. For this type I would propose the name *Sphenodiscus*, in allusion to its sharply-cuneate periphery.

8. This is not a true Ammonite, according to the latest classifications of this group of *Cephalopoda*, but it is more nearly allied to some of the forms included by Mr. Hyatt in his group *Pluroceras*. Indeed, although unquestionably a cretaceous species, I cannot see how it can be properly placed in a distinct group from the middle liassic species *A. spinatus*, Brug., which Mr. Hyatt includes in *Pluroceras*, since it seems only to differ specifically from that form in having its keel more prominent, and another series of obscure nodes on the costæ at their inner ends, with a few smaller intermediate costæ, generally without nodes, between the larger nodiferous ones. If, however, there is anything in the development of these shells that would place them in different groups, the cretaceous group, including the form under consideration, might be appropriately termed *Prionocyclus*, and would include *A. percarinatus*, H. and M., and *A. Woolgari*, of the English gray chalk.

9. I am led to think, from the comparison of more extensive collections that have come in since I proposed the name *Unio vetustus* for one of the Utah forms, that it is only a more depressed variety of *U. priscus*, M. and H.

10. It is with considerable doubt that I refer this shell to *U. tellinoides* (=*Mya tellinoides*, Hall, in Frémont's Report, Pl. III, figs. 1 and 2), the mature specimens being generally three or four times as large as that represented by Prof. Hall's larger figure, and proportionally less depressed, with the posterior margin more broadly rounded or subtruncated. Still, by following the lines of growth, it may be seen that when the shell had only attained the same size as that figured by Prof. Hall, it must have presented a very similar outline. None of them, however, seem to have the beaks so nearly central, or quite so elevated, as represented by his Figure 2, which may have been drawn from a distinct species from that represented by Figure 1.

Our specimens are generally rather thin, somewhat compressed, longitudinally ovate in form, with one rather oblique cardinal tooth in the right valve, and one or two smaller ones in the left. The lateral teeth are long, a little arched, and consist of one in the right and two in the left valve. The surface only shows lines of growth, and some traces of a few very small longitudinal wrinkles near the immediate points of the beaks, which are rather depressed, and placed about one-third the length of the valves from the anterior end. Should this form be found to be distinct from that named by Prof. Hall, it may be called *U. subcompressus*.

It may be proper to remark here, that nearly or quite all of the shells figured by Prof. Hall, on Pl. III of Frémont's Report, although there referred to marine genera, are really, as suspected by him, fresh-water types.

11 This is probably the *Cerithium tenerum*, Hall (see Frémont's Report), and is a true *Goniobasis*. In a genus like this, however, containing so many closely-allied species, it is scarcely possible to identify, with confidence, a form only known from a three or four-line description and figures of imperfect specimens. At one time I had supposed the species, for which I have here proposed the name *G. chrysalis*, to be the *tenera*. But specimens of the form I have above referred doubtfully to that species, having been brought in from that region among the later collections, I find, on comparison, that they agree more nearly in most respects with the figures and description of the species *tenera*; while, at the same time, they are clearly distinct from that I had at first supposed to be the *tenera*, and hold a much higher posi-

16. *Goniobasis nodulifera*, Meek,[12]; Barrel Springs, Wyoming. Miocene.
17. *Goniobasis Carteri*, Conrad; Barrel Springs, Wyoming. Miocene.
18. *Goniobasis chrysalis*, Meek; Sulphur Creek and Bear River, Utah. Eocene.
19. *Goniobasis Simpsoni*, Meek; Fort Bridger, Wyoming.
20. *Pyrgulifera humerosa*, Meek; Sulphur Creek, Bear River City, and Parley's Park, Utah, and Gilmore, Wyoming. Eocene.
21. *Viviparus paludinæformis*, Hall? (sp.)[13], Henry's Fork, and Green River, Arctic Springs, &c., Wyoming. Eocene.
22. *Viviparus Conradi*, M. and H.; Sulphur Creek, on Bear River, Utah. Eocene.
23. *Viviparus? Wyomingensis*, Meek, (new species, see description); Henry's and Black's Forks, and Church Buttes. Miocene.
24. *Melantho* (*Campeloma*) *macrospira*, Meek (new species); Sulphur Creek, Bear River City, and Parley's Park, Utah. Eocene.
25. *Physa* (one or two undetermined species); Church Buttes, Utah. Miocene.
26. *Planorbis spectabilis*, Meek; Henry's Fork. Miocene.
27. *Planorbis* (undetermined species); Church Buttes. Miocene.
28. *Rhytophorus priscus*, Meek; Sulphur Creek, Utah. Eocene.
29. *Bythinella? gregoria*, Meek (new species, see description); Pacific Springs, Wyoming. Miocene.
30. *Cypris*, (undetermined species); Fort Bridger and Pacific Springs. Miocene.

DESCRIPTIONS OF NEW SPECIES AND GENERA.*

Carboniferous species.

EDMONDIA ASPENWALLENSIS, (MEEK.)

Shell ovate, moderately convex; anterior side short and subtruncated, or more or less rounded; posterior margin rounded; pallial margin forming a semiovate curve, being more abruptly rounded up anteriorly than behind; cardinal border rather short, and rounding into the posterior outline; beaks moderately prominent, oblique, only about one-fourth to one-fifth the length of the valves from the anterior margin. Surface marked with more or less regular and distinct concentric ridges and striæ.

Length, 1.40 inches; height, 1.04 inches; convexity, about 0.70 inch.

It may possibly have been a variety of this species that was figured by Professor Geinitz under the name *Astarte gibbosa* (McCoy), in his "Carbonformation und Dyas in Nebraska" (Pl. I, Fig. 23), as we know it to occur at the same locality from which his specimen was obtained. His figure, however, would seem to represent a more rounded or shorter and less depressed shell, with a broader posterior outline and more gibbous beaks. At any rate, the shell under consideration is very distinct from that named by Professor McCoy, and is certainly not an *Astarte*, as its internal casts show no indications of the hinge characters of that genus, but on the contrary, impressions apparently like those left by the

tion in the series. These specimens are also extremely abundant, while those of *G. chrysalis* are rare, and hence it is more probable that the former is the species named in Frémont's Report.

It is worthy of note, that the very abundant shell, here referred doubtfully to Professor Hall's species, is exceedingly variable in its ornamentation, some specimens having the vertical costæ rather strongly developed on all the volutions, while others have them only on the upper ones; and on still others they are nearly or quite wanting on all the volutions so as to leave only the finer revolving lines, and yet we see all gradations between these extremes.

[12] This is the form figured and described in Frémont's Report under the name *Cerithium nodulosum*. As it is a true *Goniobasis*, however, and Doctor Lea had previously described a species of that genus under the name *nodulosa*, it is necessary to propose a new name for the Utah species.

[13] It is not possible, from the published figure and description of the species called *Turbo paludinæformis*, in Frémont's Report, to decide, with confidence which one of several species of *Viviparus* and *Melantho*, now known from the tertiary fresh-water deposits of the Green River country, that name was originally proposed for. From the nature of the matrix, however, and its association with the species described under the name *Cerithium nodulosum*, it is much more probable that the shell I have here referred doubtfully to *Viviparus paludinforæmis*, is really the form originally described as *Turbo poludinæformis*, than the less-abundant species of *Melantho*, from the Bear beds, composed of a different material.

* Drawings of these fossils are in course of preparation, to be published along with full descriptions in final report.

cartilage processes, in the casts of *Edmondia*, though I am not quite sure that it belongs properly to the latter genus. It is a rather thin shell, that leaves impressions of the concentric ridges rather distinct on internal casts, where very faint traces of radiating lines are also sometimes seen. Its muscular and pallial impressions are obscure, and not well known.

Locality and position. This shell has a very wide distribution in the coal measures of this country, through nearly the entire thickness of which it ranges. The typical specimen was found in the upper part of the coal measures at Aspenwall, on the Missouri River, in Southeastern Nebraska. It also occurs at nearly all the other outcrops along the Missouri in that region, as well as in the upper and lower part of the coal measures of Illinois; likewise in the lower part of the seres in West Virginia, and apparently at Box Elder Cañon, on the North Platte, Wyoming. The specimens from the latter locality, however, are shorter and more gibbous, and agree more nearly with Professor Geinitz's figure.

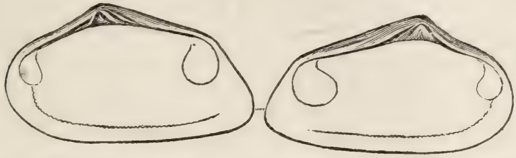
Cretaceous forms.

GENUS CRASSATELLINA, (MEEK.)

Shell subtrapezoidal, equivalve, inequilateral, with the margins closed and smooth within. Hinge with two cardial teeth and one elongated anterior and posterior lateral tooth in each valve. Anterior cardinal tooth of left valve trigonal and deeply emarginate below; posterior very oblique, and separated from the other by an oblique pit divided longitudinally by a thin lamina. Cardinal teeth of right valve diverging, with a triangular pit between for the reception of the triangular cardinal tooth of the other valve; anterior one small, and connected with the anterior lateral tooth; posterior one larger, oblique, and divided longitudinally by a deep slit for the reception of the lamina in the corresponding pit of the other valve. Ligament external (?) Muscular impressions shallow. Pallial line simple (?) Surface without radiating markings.

The typical and only known species of this genus has very much the external aspect of a *Crassatella*, from which, however, it is widely removed, generically, by its hinge characters, though probably belonging to the same family. Its muscular impressions are very faintly marked, as is also the case with its pallial line, which I have not been able to trace along its entire length, though enough of it can be seen to leave little, if any, room for doubting that it is simple. Its lateral teeth are elongated parallel to the cardinal margin, the posterior being rather remote from the cardinal, while the anterior one in the right valve connects at its posterior end with the small anterior cardinal, and in the left extends back to the small pit for the reception of this anterior cardinal tooth of the right valve, just in front of the larger, trigonal cardinal tooth of the left valve. The anterior lateral tooth of the right valve seems to fit under that of the left, and the posterior one of the right over that of the left, though I am not positively sure of this. The cardinal teeth are very peculiar, those of the right being rather widely diverging, with the very oblique posterior and larger one so deeply divided longitudinally by a very narrow slit, that it may possibly sometimes rather present the character of two teeth, though the posterior half seems scarcely prominent enough to be considered a distinct tooth. The principal or anterior trigonal cardinal tooth of the left valve, which fits between the two diverging ones of the right, is sometimes so deeply emarginate below that it might almost be described as ∧-shaped, while the posterior cardinal of this valve is directed very obliquely backward and downward, and compressed. The thin lamina dividing longitudinally the pit between this oblique tooth and the trigonal, emarginate one, is another peculiar feature.

CRASSATELLINA OBLONGA, (MEEK.)



A shows hinge and interior of right valve; B hinge and interior of left valve; both 2 diam.

Shell small, short oblong-subtrapezoidal in outline, less than twice as long as high; valves rather distinctly convex, with flattened sides; anterior margin rounded; pallial margin nearly straight, or sometimes slightly sinuous along the middle; posterior oblquely truncated above and narrowly rounded below; dorsal outline sloping rather abruptly in front of the beaks and less distinctly so behind; beaks moderately prominent, and placed a little in advance of the middle; posterior umbonal slopes prominently rounded from the beaks to posterior basal extremity; posterior dorsal region above the umbonal prominences flattened; flanks sometimes a little concave toward the pallial margin. Surface with rather distinct lines of growth.

Length, 0.73 inch; height, 0.32 inch; convexity, 0.30 inch.

Specifically, this shell is more nearly like the form I have described from the cretaceous near Cañon City, under the name *Mactra? Cañonensis*, than it is like any other form with which I am acquainted; though it differs too widely to be confounded with that shell, even where the hinge could not be seen. They both have so much the appearance of the genus *Crassatella*, externally, that few would hesitate to refer them to that genus where their external characters only could be examined.

Locality and position: Twelve miles southwest of Salina, Saline County, Kansas; Dakota Group of the Upper Missouri cretaceous series. Collected by Professor B. F. Mudge.

PACHYMYA? TRUNCATA. (MEEK.)

Shell small, longitudinally oblong, very convex; posterior side long, distinctly and rectangularly truncated, apparently closed; pallial margin nearly straight, and slightly sinuous along its entire length; anterior margin truncated a little obliquely forward from the beaks to the rather prominent and abruptly-rounded, or subangularly-anterior basal extremity; cardinal margin nearly straight and parallel to the base; beaks depressed nearly to the horizon of the dorsal margin, very oblique, somewhat compressed, and placed less than one-fifth the length of the valves behind the anterior extremity; posterior umbonal slopes quite prominent or subangular, and continued obliquely to the posterior basal angle, so as to divide the surface of each valve into two nearly equal, elongated, inequilateral triangles, the lower of which forms the concave flanks; anterior muscular scar small, but very deep; posterior ditto, larger, shallow, suboval; pallial line not distinctly seen, but apparently with a small sinus. Surface with rather coarse, irregular marks of growth.

Length, 1.15 inches; height, 0.55 inch; convexity, 0.58 inch.

This shell is much smaller than the typical species of Sowerby's genus *Pachymya*, which it resembles in general habit and in the thickness of its valves. Its ligament seems to have been short and rather deeply inserted behind and between the beaks. I have not seen the hinge, but judging from internal casts it would seem to be edentulous. Its peculiar oblong form and squarely-truncated posterior margin give it somewhat the aspect of a *Saxicava*, or a miniature *Panopæa*, but it differs from these genera, in having thicker valves, and nearly or quite closed margins. I am not sure that it belongs properly to the genus *Pachymya*, though it must be nearly related to that genus, which seems rather to belong to the *Mytilidæ* than to be nearly allied to *Pholadomya* or *Panopæa*, with which some have associated it.

Specifically, the shell under consideration will be readily distinguished from all of our other known cretaceous forms by its peculiar oblong, truncated form and prominent umbonal slopes, concave flanks, &c. The only other form known to me that approaches it in these characters is Mr. Gabb's *Remondia furcata*, which is a much larger shell, with more regular undulations, a more prominent base in front of the middle, a less narrowly-rounded anterior basal extremity, and a more obliquely-truncated posterior margin. Our shell also seems not to have the hinge characters of Remondia.

Locality and position: The specimen was given to Dr. Hayden at the Salt Lake, and was found in that region, but he could not ascertain the precise locality. It is almost certainly a cretaceous species.

INOCERAMUS ALTUS. (MEEK.)

Shell attaining a medium size, vertically, or a little obliquely, subovate, being in the adult higher than long, and widening from the hinge downward; moderately convex; equivalve, very inequilateral; hinge very short and ranging nearly at right angles to the longer axis in the adult, but a little more oblique in young shells; anterior side straight, long, and truncated vertically or nearly at right angles to the hinge, immediately in front of the beaks; base regularly rounded; posterior outline forming a broad, somewhat oblique, gentle curve from the posterior end of the hinge into the base; beaks nearly or quite equal, rising little above the hinge line, pointed, obliquely incurved, and placed immediately over the anterior margin. Surface of cast showing more or less regular, rather obscure concentric undulations, and faint traces of radiating markings, the latter probably not being defined on the exterior.

Height, about 6.50 inches; length, about 4.90 inches; convexity, 2.70 inches; length of hinge, about 2.40 inches.

This species belongs to the section of the genus that includes perna-like forms; that is, shells with their vertical diameter greater than their atero-posterior, and with a short hinge ranging nearly at right angles to the longer (vertical) axis of the valves, terminal or anterior beaks, etc. It differs, however, decidedly from all of the described species of that type with which I am acquainted, in being almost exactly equivalve, with its beaks also very nearly if not quite equal. In size and general appearance it reminds one of *I. nobilis*, Münster, as figured in Goldfuss' Petref. Germ., Pl. CIX, Fig. 4 and 4*a*; but it differs from that species, not only in its equal beaks, but in having its truncated anterior side straight instead of concave in outline, and its surface undulated instead of merely striated.

Locality and position: Near Medicine Bow Station, Union Pacific Railroad; Fort Pierre Group of the Upper Missiouri cretaceous section.

UNIO (BAPHIA?) NEBRASCENSIS. (MEEK.)

Shell attaining a medium or larger size, cuneate-subovate, being in the adult very gibbous anteriorly and cuneate behind; anterior side very short and rounded; posterior sloping above obliquely from the end of the hinge to the posterior basal extremity, which is narrowly rounded; basal border sinuous behind the middle, and convex in front of it; cardinal margin rather short and nearly straight or slightly arched; umbones very gibbous, but depressed, oblique, incurved, and placed near the anterior extremity; posterior umbonal slopes subangular from the beaks obliquely backward and downward to near the middle, beyond which they are continued as broadly-rounded ridges to the posterior basal extremity; below and parallel to these ridges there are also, on the flanks, one or two large, oblique, irregular, rounded plications or undulations, that continue on to the sinuous posterior basal margin, to which they sometimes impart a distorted or waved appearance. Surface otherwise smooth, excepting moderately-distinct lines of growth, which are strongly undulated in places, as they cross the oblique plications of the flanks.

Length, 4.10 inches; height, 2.36 inches; convexity, 2.07 inches.

Specimens of this large shell were brought by Dr. Hayden from Nebraska, some years back, but I have delayed describing it, with the hope that other specimens would be found that might show the nature of the hinge. It has so much the external aspect of the *Unionidæ* as strongly to impress one with the belief that it belongs to the genus *Unio*, as understood in its wider signification. It certainly has an external ligament exactly as we see in that genus; while one of the casts shows the impression of a single compressed, oblique cardinal tooth in the right valve just over the scar of the anterior adductor, and near the margin. The anterior adductor scar is rather deep and also near the margin. I have not, however, seen the small scar placed just behind that of the anterior adductor of *Unio*, in the internal casts of this shell. So far as can be made out from the casts, there would seem to have been no lateral teeth, but the specimens are not in a condition to warrant a positive opinion on this point; nor do they show the nature of the pallial line.

Locality and position: Dakota Group, or No. 1, of the Upper Missouri cretaceous, opposite Sioux City, on the Missouri, in Dakota County, Nebraska, where it occurs associated with *Cyrena arenaria*.

ARCA? PARALLELA. (MEEK.)

Shell small, longitudinally oblong, being about twice and a half as long as high, moderately convex; cardinal and pallial margins straight and nearly parallel; anterior side short and rounding up regularly from below and intersecting the cardinal margin at an obtuse angle above; posterior side long, a little wider than the other, with its margin compressed and obliquely truncated above, but rounded below; beaks depressed, somewhat flattened, incurved, not very remote, and placed about one-fifth the length of the valves from the anterior margin; cardinal area *very* narrow, and apparently smooth; muscular and pallial impressions very obscure; hinge with denticles longest posteriorly, where they are directed upward and backward at an angle of about forty-five degrees to the cardinal margin; from the posterior side they diminish rather rapidly in size and length forward, so that they become very minute and crowded between the beaks, which is as far forward as they have been traced in the specimens examined. Surface showing very fine, crowded, radiating striæ, with stronger marks of growth.

Length, 0.95 inch; height, 0.37 inch; convexity, 0.27 inch.

This is not a typical *Arca*, if we follow conchologists in viewing *A. Nocæ* as the type of the genus, because it wants the broad, divaricately-furrowed cardinal area, and is not gaping in the anterior ventral region. Its hinge denticles are also more oblique and longer posteriorly, more like those of *Scaphula*. In form and general appearance it is very much like some species of *Macrodon*, but its hinge characters are widely different. I know of no established section of the old genus *Arca* into which it could be properly placed, and if it is thought desirable to have a section for such forms, they might be separated under the name *Arcina*.

Locality and position: Twelve miles southwest of Salina, Saline County, Kansas; Dakota Group of the Upper Missouri cretaceous series. Professor B. F. Mudge.

YOLDIA MICRODONTA, (MEEK.)

Shell small, longitudinally subovate, rather compressed; anterior margin more or less narrowly rounded, being generally more prominent above the middle; pallial margin forming a semiovate curve, being more prominent before than behind the middle, and curving up gradually and obliquely at both ends; posterior side compressed, and with its margin narrowly rounded, or almost subangular at its connection with the hinge above; cardinal margin sloping gradually from the beaks, the posterior slope being very slightly concave in outline, and the anterior nearly straight; beaks rather depressed and placed a little in advance of the middle; hinge line equaling about three-fourths the entire length, and provided with very fine, regular, pointed denticles, of which twenty-six may be counted behind and twenty before the beaks, in each valve. Muscular and pallial impressions very obscure, and not visible on internal casts. Surface not well known.

Length, 0.50 inch; height, 0.28 inch; convexity, 0.14 inch.

In general outline, and the nearly central positions of its beaks, this shell bears some relation to *Yoldia bisulcata*, M. and W., from the Fox Hills Group of the Upper Missouri cretaceous, but it is a very decidedly more compressed species; and, judging from impressions left in the matrix, it was evidently less strongly striated. Indeed it seems to have been nearly smooth, in which character, as well as in some other respects, it is probably more nearly related to *Y. Evansi*, M. and W., from which it differs in being proportionally shorter, higher, and more compressed. Among European species, it is represented by such forms as *Yoldia scapha* (*Nucula scapha*, d'Orbigny, Palæont., Francaise, t. iii, Pl. 301, Fig. 1–3), from which it also differs in being more compressed, with the posterior side wider, and the posterior dorsal slope distinctly less concave in outline.

Locality and position: Twelve miles southwest of Salina, Kansas, from a brown sandstone of the age of the Dakota Group of the Upper Missouri cretaceous. Discovered by Professor Mudge, of the Kansas Agricultural College.

CORBICULA? NUCALIS, (MEEK.)

Shell small, trigonoid-subcircular, moderately gibbous, the greatest convexity being above the middle; pallial margin forming a semi-elliptic curve; posterior margin subtruncated or rounded; anterior margin rather more narrowly rounded; dorsal outline sloping rather abruptly and nearly equally, with slight convexity in front and rear of beaks, the anterior slope being somewhat more abrupt than the other; beaks nearly or quite central, curved inward and slightly forward; posterior dorsal surfaces a little flattened; post-umbonal slopes somewhat prominent, or sometimes almost subangular in internal casts; muscular impressions shallow and oval; pallial line with a small obtuse sinus. External surface unknown; surface of internal casts smooth.

Length, 0.47 inch; height, 0.42 inch; convexity, 0.26 inch.

Impressions of the hinge of this little shell, left in the matrix, show that it has elongated anterior and posterior lateral teeth that are striated transversely, as in *Corbicula*. In the left valve there is one elongated anterior, and one similar posterior lateral tooth, each of which fits into a corresponding furrow in the margin of the other valve. Immediately above this furrow, in the posterior and anterior margin of the right valve, there is a smaller linear, striated lateral tooth, while the margin below the furrow seems hardly to project enough to be properly regarded as a second anterior and posterior lateral tooth. The specimens of the impressions of the cardinal teeth are not so clearly seen, being mainly hidden behind the cast of the umbones, in the only specimen that I have seen with this part of the hinge well preserved. So far as they can be made out, they seem to be much as in the existing species of *Corbicula*, excepting that the anterior cardinal tooth of the left valve is directed almost horizontally forward instead of obliquely forward and downward; it is also much compressed from above and below, and very prominent, and curved upward. The corresponding tooth of the other valve is much smaller and overlaps that of the right valve. Behind this prominent anterior cardinal tooth of the left valve, I think I have seen two other diverging and emarginate cardinal teeth, with pits for two corresponding diverging teeth in the right valve. The number and arrangement of the teeth of the hinge would, therefore, if correctly understood in the specimen, seem to be almost exactly as in *Corbicula*, with the exception of the horizontal direction of the anterior cardinal teeth, and the prominence of that of the left valve.

It is quite possible, however, that if we had specimens showing more clearly the cardinal teeth, we might find differences enough to warrant the establishment of a distinct section, allied to *Corbicula*.

Locality and position: Twelve miles southwest of Salina, Kansas; Dakota Group of the Upper Missouri cretaceous series. Professor Mudge.

CORBICULA? SUBTRIGONALIS, (MEEK.)

Shell oval-subtrigonal, about one-fourth longer than wide, rather gibbous, the greatest convexity being above the middle; basal outline forming a semi-elliptic curve; extremities rather narrowly and very nearly equally rounded; beaks somewhat depressed and very nearly central; dorsal outline sloping before and behind the beaks, the latter slope being convex and the former nearly straight. Surface only showing five lines of growth. Pallial line with a small, obtusely-subangular sinus.

Length, 1.16 inches; height, 0.90 inch; convexity, about 0.66 inch.

The only cast of the hinge of this species I have seen, is that of a left valve. It shows the impressions of the same elongated and striated lateral teeth seen in the last. The cardinal teeth, however, seem to have unfortunately been much injured by maceration or erosion, before they left their imprint in the matrix. It shows the mold of a prominent triangular anterior cardinal tooth in front, apparently like that of the last, and behind this there are remains of two prominences, that look like they might be casts of two somewhat diverging cardinal teeth in the right valve, with impressions for two other cardinal teeth in the left; hence, so far as can be made out, the teeth of the hinge seem to agree with those of the last-described species. Specifically, however, this form differs from the last in its more depressed and transverse outline, as well as in having its lateral extremities more nearly equal and more narrowly rounded; the posterior margin not being truncated as in the last.

Locality and position: Same as last. Collected by Professor Mudge.

CARDIUM PAUPERCULUM, (MEEK.)

Shell small, very thin, rather compressed, subovate or subcircular; beaks moderately prominent and nearly central; surface ornamented by about thirty regular, simple, distinctly defined, radiating costæ, which about equal the intermediate furrows, and (owing to the thinness of the valves) are well-defined internally, and thus impart a plicated or crenated character to the margins; crossing these are numerous very regular, well-defined, delicate marks of growth, that are usually less distinct on the posterior third, but give a neatly crenulated appearance to the costæ farther forward.

The specimens yet seen of this little shell are rarely more than about 0.50 inch in diameter, and are all more or less flattened or otherwise distorted. Sometimes they are distorted by antero-posterior pressure, so as to present somewhat the appearance and outline of a *Lima*, being higher than wide, and more or less oblique; while in other examples they are distorted by vertical pressure, so as to present little or no obliquity, and to show a greater antero-posterior diameter than height. I have not seen the hinge, but some impressions in the matrix show that it has anterior and posterior lateral teeth like those of *Cardium;* it, however, does not belong properly to the typical section of that genus.

Locality and position: Fort Benton Group, or No. 2 of the Upper Missouri cretaceous series, at the Oil Springs, twenty miles west of Fort Bridger, Wyoming Territory.

CARDIUM (PROTOCARDIA) SALINAENSE, (MEEK.)

Shell small, orbicular-subtrigonal, slightly longer than high, rather gibbous; pallial margin forming a semicircular curve; anterior margin rounded, most prominent at or a little above the middle, where it is sometimes inclined to be rather narrowly rounded, while below this it curves off obliquely into the base; posterior margin broader than the anterior, and faintly subtruncated, or broadly rounded; beaks moderately prominent, convex, and incurved, located slightly in advance of the middle; dorsal outline sloping more abruptly in front than behind the beak's; surface ornamented on the sides and front by comparatively rather large, rounded, very regular, concentric costæ, separated by smaller furrows, and on the posterior side by sixteen to twenty-two smaller radiating costæ, that are provided with very regularly-disposed, little, vaulted, scale-like prominences, formed by undulating marks of growth.

Height, 0.66 inch; length, 0.68 inch; convexity, about 0.49 inch.

This little shell is allied to *C. peregrinosum*, d'Orbigny, and *C. Hilla-*

mum, Sowerby. It is much smaller than the latter, however, and has a different outline, not being near so truncated behind, nor so regularly rounded in front. Its concentric costæ are likewise proportionally much larger and less numerous, while the radiating ribs on its posterior side differ in being provided with the numerous little projections mentioned in the description. In the latter character it agrees more nearly with *C. peregrinosum*, d'Orbigny. It also differs from the latter, however, in having its concentric costæ proportionally much larger and less numerous, and the radiating ones straighter and occupying a larger area of the valves, while the anterior margin is less broadly and regularly rounded in outline.

Locality and position: Twelve miles southwest of Salina, Saline County, Kansas; Dakota Group of cretaceous. Professor Mudge, collector.

CARDIUM KANSASENSE, (MEEK.)

Shell rather small, oval-suborbicular, being generally slightly higher than the antero-posterior diameter, and rather gibbons, with the greatest convexity usually above the middle; pallial margin rounded, or subsemicircular in outline, being in most cases more prominent behind the middle; anterior margin more or less regularly rounded; posterior outline rounded, or very faintly subtruncated; dorsal outline sloping abruptly from the beaks before and behind; beaks elevated, gibbous, incurved, and subcentral, or a little in advance of the middle, and but slightly oblique; posterior dorsal slopes somewhat flattened; surface marked by numerous regular, simple, radiating striæ, or small costæ, that are sometimes interrupted by marks of growth. Hinge strong, with cardinal and anterior lateral teeth stout; posterior lateral remote and less prominent. Anterior muscular scar rather deep; posterior shallow. Scar of pedal muscle (?) small, very deep, and situated on the inner anterior side, and near the points of the beaks, almost opposite the cardinal teeth.

Length, 0.94 inch; height, 1 inch; convexity, about 0.63 inch.

This and the last-described species are the two most common shells found at the locality where they were obtained, and being, like the other fossils with which they are associated, found in the condition of casts, not always showing even traces of the surface markings, it is sometimes difficult to distinguish them. Where any remains of the surface markings can be seen, however, they can be at once distinguished by the concentric costæ on the sides and front of the former, and the radiating costæ on the corresponding parts of that under consideration. The latter seems also to have generally attained a somewhat larger size. The inner margins of both appear, from the casts, to be generally nearly smooth, though some of the casts of the form under consideration show faint traces of what seem to have been crenulations, near the middle of the base. I at first thought the peculiar projecting point left by what I have supposed might be the scar of the pedal mucles, near the point of each beak of internal casts, might distinguish the form under consideration; but this is also seen on some of the casts of the other species, which, likewise, has the hinge teeth very similar, so that the only sure means of distinguishing them seems to be the surface markings. These markings are sometimes distinctly and sharply impressed in the matrix, and by taking gutta-percha impressions from these molds, the nature of the surface markings can be very clearly made out. No traces of nodes, or projecting points of any kind, exist on the costæ of this species. In some respects it resembles *C. Cottaldinum*, d'Orbigny (Pal.

Fr. III, Pl. 1-4), from the Neocomian; but it is rather more coarsely striated, and wants the posterior dorsal impression of that shell, from which it also differs in being less evenly convex.

Locality and position: Same as last. Discovered by Professor Mudge.

MACTRA? CAÑONENSIS, (MEEK.)

Shell small, very thin, transversely subovate, rather compressed or moderately convex, with length about once and a half the height; anterior side rounded; posterior side longer, narrower, and obliquely subtruncated at the extremity; pallial margin forming nearly a semi-ovate curve, being most prominent anteriorly, straight or very slightly sinuous behind the middle, and rounding up very abruptly to the lower part of the truncated posterior margin; dorsal outline nearly straight and sloping to the truncated posterior, and declining more abruptly in front; beaks small, moderately prominent, and placed one-third the length of the valves from the anterior margin; posterior umbonal slopes rather prominent to the posterior basal extremity, while the sides in front of this prominence are flattened, or even very slightly concave below. Surface with rather regular but distinct lines and furrows of growth. Muscular impressions shallow; posterior round-oval; anterior narrower, with a slender prolongation above; pallial line with a shallow, rather rounded sinus.

Length, 0.78 inch; height, 0.53 inch; convexity, 0.31 inch.

At the same time that I refer this species, for the present, to the genus *Mactra*, I really do not believe that it belongs properly to that genus, as restricted by late authorities on conchology. I merely place it there, however, because its hinge is unknown, and it presents some characters indicating relations to that group. In form it is very unlike *Mactra*, and more nearly resembles *Crassatella*. Its thinness and sinuous pallial line, however, at once forbid its reference to that group, while the latter character, and especially a triangular fissure seen in the hinge margin between the beaks, as in *Mactra* (*Schizodesma*), indicate relations to that genus. Its hinge, however, will probably be found presenting characters that warrant its separation as a distinct genus, judging from its general physiognomy.

Locality and position: Cañon City.

GENUS ARCOPAGELLA, (MEEK.)

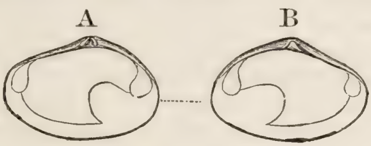
Shell equivalve, more or less nearly equilateral, longer than high, with margins closed all around and smooth within. Hinge with two cardinal, and one anterior and one posterior lateral teeth in each valve. Left valve with anterior cardinal tooth larger than the posterior and trigonal in form, but sometimes rather deeply emarginated below, placed directly under the beak; posterior cardinal tooth small, slender, and ranging obliquely backward and downward close to the larger one, so as to leave only a slender pit between, corresponding to another on the anterior side of the principal cardinal tooth, which two pits are for the reception of the cardinal teeth of the right valve; anterior and posterior lateral teeth both elongated parallel to the cardinal margin, the former approaching more nearly to the cardinal teeth. Right valve with, under the apex, two diverging, slender cardinal teeth, like the posterior one of the other valve, with a triangular pit between them for the reception of the principal cardinal tooth of the other valve; anterior one more oblique than the other, and nearly or quite connecting with the lateral tooth on that side; lateral teeth like those of the left valve; the anterior one apparently fitting under that of the other valve, and the posterior above that of the other. Muscular impressions shallow; pallial impression with a moderate rounded sinus, directed obliquely forward and upward. Ligament unknown, but believed to be external. Surface without ornamentation.

After searching in vain to find some defined group under which I could range this shell, with a reasonable degree of probability of its properly belonging to the same, I have concluded to propose a new genus for its reception. It seems to be related to *Arcopagia*, but differs in having anterior and posterior lateral teeth in both valves, as well as in the form of the anterior cardinal tooth of the left valve and its arrangement with relation to the other. At first I was inclined to think it might find a place in Mr. Conrad's cretaceous genus *Tellimera*, but a sketch of the hinge of his type received from him shows the latter to be quite distinct, having a double anterior lateral tooth in the right valve, and the cardinal teeth of the same consisting of one bifid very oblique cardinal tooth, and immediately behind this a minute vertical second cardinal. The hinge plate of his genus is also distinctly wider on the anterior side than in the type under consideration.

It is somewhat remarkable that the hinge structure of the type of this genus is, in most respects, very similar to that of the group for which I have proposed the name *Crassatellina*, while the whole aspect of the two shells is so entirely different that I can scarcely doubt that they really belong to two distinct families—*Crassatellina* probably belonging to the *Crassatelledæ*, and *Arcopagella*, apparently to the *Tellinidæ*. As closely as their hinges resemble, however, a critical comparison of the accompanying cuts will show them to present important differences of details.

It is probable this genus will be found to include other tellinoid cretaceous shells, the hinges of which are yet unknown.

ARCOPAGELLA MACTROIDES, (MEEK.)



A, hinge and interior of right valve.
B, hinge and interior of left valve; both nat. size.

Shell longitudinally-subovate, width or height about two-thirds the length, rather compressed or moderately convex; pallial margin forming a regular semi-elliptic curve from end to end; anterior margin narrowly rounded, with the most prominent part near the middle; posterior border more narrowly rounded than the anterior, particularly below, where there seems to be the faintest possible tendency to form a flexure or fold; beaks moderately prominent, located very nearly centrally; dorsal outline sloping almost equally before and behind the beaks, but with the anterior slope slightly concave in outline above, and the posterior a little convex; muscular impressions faintly marked and rather narrow subovate; pallial line with its rather shallow, broadly-rounded sinus directed very obliquely forward and upward. Surface apparently with only fine lives of growth.

Length of one of the larger specimens, 0.78 inch; height, 0.53 inch; convexity, about 0.26 inch.

This shell will be readily distinguished from the Tellinas of our cretaceous rocks by its shorter, slightly more convex, subtrigonal, or subovate nearly equilateral form, even where its hinge cannot be seen. In some respects it looks externally like a compressed and depressed *Mactra*. I am unacquainted with any tertiary species with a similar hinge.

Locality and position: Twelve miles southwest of Salina, Saline County, Kansas; Dakota Group of Upper Missouri cretaceous. Professor B. F. Mudge.

TELLINA SUBSCITULA, (MEEK.)

Shell small; elliptic-suboval, much compressed; pallial margin forming a regular semi-elliptic curve; extremities narrowly rounded, the posterior being a little shorter, with a very obscure flexure, and more abruptly or narrowly rounded below; dorsal outline sloping gently in both directions from the beaks, the posterior slope being a little convex in outline, and the anterior nearly straight; beaks depressed, compressed and placed a little behind the middle; muscular impressions moderately distinct, the posterior one being broader than the other; pallial sinus very deep, nearly horizontal, and rather broadly rounded. Surface with only fine lives of growth.

Length, 0.84 inch; height, 0.47 inch; convexity, about 0.15 inch.

This shell is much like *Tellina scitula*, M. and H., from the upper member of the Upper Missouri cretaceous series; but on comparison it is found to be proportionally more depressed, while its pallial sinus is very different, being much broader and more obtusely rounded at the end. Impressions of its surface in the matrix also indicate less strongly-defined lines of growth. Casts show that it has no lateral teeth.

Locality and position: Same as last. Professor Mudge.

TAPES WYOMINGENSIS, (MEEK.)

Shell elongate-subelliptic in outline, much compressed; extremities nearly equally rounded; pallial margin straight and nearly parallel to the dorsal, but rounding up regularly at both ends; dorsal side straight, or very slightly convex in outline; beaks depressed nearly or quite to the dorsal margin, and placed about one-fourth the length of the valves from the anterior end; anterior muscular impression ovate, rather well defined, and with its longer diameter ranging vertically; pedal scar distinct near the upper end of that of the anterior adductor; posterior muscular impression very shallow; pallial line with its sinus rather deep, horizontal, and obtuse at the end. Surface with lines and some small ridges of growth.

Length, 1.70 inches; height, 0.82 inch; convexity, about 0.28 inch.

The only specimens of this species yet obtained are mainly casts retaining some portions of the shell. They give very little idea of the nature of the hinge beyond the fact that it seems to have three diverging cardinal teeth, the exact form and arrangement of which cannot be made out. The general expression of the shell, however, is very nearly that of some European cretaceous forms that seem to have essentially the hinge characters of *Tapes*, though they may not be exactly congeneric with the recent species of that genus. Among the foreign species our shell seems to be most nearly represented by *Venus fragilis*, d'Orbigny (from the cretaceous of France), which is not a true *Venus*, but has been referred by Mr. Zittel to the genus *Tapes*. (See Bivalven der Gosaug., Nord Alpen.)

Compared with d'Orbigny's figure and description of his *V. fragilis*, given in the Palæont. Francaise, our shell differs in being regularly rounded instead of truncated posteriorly. It is also straighter on the basal margin, and more broadly rounded in front. In some of these characters it agrees more nearly with Professor Zittel's figures, which I suspect may represent a distinct species from that figured by d'Orbigny. Still it differs from Professor Zittell's figures, in having its anterior margin more broadly rounded, and its pallial margin straighter in outline.

Locality and position: Mouth of Deer Creek, on North Platte, in Wyoming Territory; Fox Hills Group of the Upper Missouri cretaceous series.

LEPTOSOLEN CONRADI, (MEEK.)

Shell elongate-oblong, nearly three times as long as high, moderately convex; dorsal margin straight, pallial margin more or less nearly straight, and subparallel to the dorsal, being a little convex in outline in front of the middle, thence ascending obliquely forward to the narrowly-rounded anterior end; posterior margin truncated vertically, but rounding abruptly into the dorsal and ventral borders above and below; beaks not raised above the dorsal margin, and very inconspicuous, their position only being indicated externally by the curves of the marks of growth, located about one-third the length of the valves from the anterior end; surface only showing fine lines of growth.

Length, 1.04 inches; height, 0.36 inch; convexity, 0.28 inch.

Internal casts of this species show the impression of the strong internal ridge, extending directly downward from the beaks, and gradually dying out below the middle of the valves. These casts also show the impression of a *single* small tooth in the right valve, just in front of the upper termination of the deep furrow left by the strong internal ridge. From these characters it is evident that this genus is allied to *Siliqua*, Mühlfeldt (*Leguminaria*, Schum.), but differs, as pointed out by Mr. Conrad, in having but a single hinge tooth in the right valve, instead of three in each valve. It almost certainly includes *Leguminaria Moreana*, d'Orbigny (Pal. France Ter. Cret., III, Pl. 350, Figs. 8, 9, 10), and *L. Petersi*, Reuss (*Siliqna Petersi*, Zittel, Bivalven der Gos., Nordöstlien Alpen, taf. 1, Fig. 3), both of which, like Mr. Conrad's type, are cretaceous species.

Compared with Mr. Conrad's typical species, *L. biplicata* (*Siliguaria biplicata*, Con., Jour. Acad. N. Sci., III, Pl. 34, Fig. 17), our shell is seen not only to be much smaller and proportionally shorter, but to differ in not having the two broad prominences radiating forward and downward from the beak of each valve, as in that species, though it shows a single very obscure, broad prominence extending directly downward under the beaks, and widening as it descends. In front and behind this there is also, in each valve, a scarcely perceptible concavity. This broad prominence also imparts a slight convexity to the outline of the base, just at the point where the base in Mr. Conrad's species is sinuous.

It is probably more nearly allied to *Leptosolen Moreana*, d'Orbigny (sp.), already cited, but differs from d'Orbigny's figure in being decidedly straighter on the dorsal margin, and wider, as well as more distinctly truncated posteriorly. Compared with *Lept. Petersi*, Reuss (sp.), as figured by Professor Zittel, our species will be readily distinguished by having its internal ridge at right angles to the dorsal margin, instead of extending obliquely backward and downward; also in having its dorsal margin straight from end to end, instead of declining forward from the beaks.

Locality and position: Twelve miles southwest of Salina, Kansas; Dakota Group of the cretaceous series of the Upper Missouri. Professor Mudge.

ANISOMYON CENTRALE, (MEEK.)

Shell depressed, conical, somewhat wider than high, apex central, or very nearly so; slopes nearly equal all around, or with sometimes the anterior and sometimes the posterior sides a little convex, and the others more nearly straight; aperture circular; surface apparently smooth, excepting obscure lines of growth, crossed by several irregular, diverging, obscure, radiating ridges and more strongly defined furrows; the former being mainly on the posterior and the latter on the interior and lateral slopes.

Breadth of largest specimen seen, 1.16 inches; height about 0.95 inch.

I have seen only two specimens of this species, and these are internal casts, with merely some fragments of the very thin shell remaining, while the extreme apex of both is broken away. The radiating furrows are rather distinctly defined on the anterior slope of the internal cast, while one (apparently not exactly the middle one) is narrower and distinctly deeper than the others on each side of it, which latter are about twice as wide, shallow, and often somewhat divided by a small ridge down the center of each. On the posterior slope one of the ridges is more strongly defined than the others, especially near the apex, and seems to correspond to the deeper furrows of the anterior slope, though not exactly opposite to it. The broken apex in one of the specimens looks as if it might have curved a little backward, though in the other it evidently curved forward at the point, if I have rightly determined the relative sides.

One of the specimens shows obscure traces of the oval muscular scar on each side, and these are connected across the side I regard as the anterior, by a slender line, but the specimen being a little worn on the opposite or posterior side, I have been unable to make out the broader interrupted band that ought to pass around the posterior side, if the species really belongs to this genus.

This species will be readily distinguished from all of the others yet known from the far western cretaceous rocks by its conical form and elevated apex.

Locality and position: Box Elder and Colorado City, Colorado; Fox Hills Group of the Upper Missouri cretaceous series.

TURRITELLA KANSASENSIS, (MEEK.)

Shell elongate-conical, or gradually and regularly tapering from below to the apex, with the lateral slopes of the spire straight; volutions eight to ten, increasing regularly in size, flattened, or only very slightly convex; last one rounded below; suture nearly linear; aperture ovate. Surface with small, thread-like, revolving lines, varying much in their arrangement and distinctness, but usually more strongly defined on the lower half of the last turn; lines of growth very fine, obscure, and strongly arched or sigmoid, so as to indicate a rather deep sinuosity in the outer lip above the middle.

Length of large specimen, 1.10 inch; breadth, 0.34 inch; divergence of slopes of the spire, about 22°.

This shell varies much in its surface marking, some of the specimens appearing almost smooth, or only showing faint indications of a few revolving lines, while others show a few distantly-separated, very slender, raised lines. In still others five or six well-defined slender lines may be seen on some of the volutions, and a smaller number of less distinctly-defined ones on the other turns. The arrangement of these lines and their comparative size on different individuals, as well as on different parts of the same specimen, vary much. Usually the upper turns near the apex of the spire appear to be smooth, though this may be partly due to accidental erosion before the shells were imbedded in the matrix.

Locality and position: Twelve miles southwest of Salina, Kansas; Dakota Group of cretaceous. Professor B. F. Mudge, collector.

TURBO MUDGEANUS, (MEEK.)

Shell small, turbinate, about as high as wide; spire moderately prominent; volutions, four and a-half to five, increasing rather rapidly in size, convex; last one somewhat obliquely flattened below, and laterally compressed or flattened around the middle of the outer side; suture more or less channeled; aperture circular; outer lip thin and oblique; columella arched and flattened below; axis imperforate. Surface ornamented by strong, raised, oblique lines of growth, which are crossed by four equidistant, rather sharp, revolving carinæ, only three of which are seen on the volutions of the spire.

Height, 0.66 inch; breadth, about 0.64 inch; divergence of slopes of the spire about 75°.

This shell is evidently related to *Turbo tricostatus*, d'Orbigny (Palæont. Fr. Ter. Cret., t. II, Pl. 186 bis, fig. 5, 6), but clearly differs in having its spire decidedly more depressed, and in having four revolving carinæ on its body volution, instead of only three. Its body whorl is also more rounded, in consequence of its greater convexity on the upper side, which also imparts a more rounded outline to its aperture. It likewise wants the small umbilicus said to exist in d'Orbigny's species, and does not show the lower carina of the body turn above the suture on those of the spire.

The specific name is given in honor of Professor Mudge, of the Kansas State Agricultural College, to whom I am indebted for the typical specimens of this, as well as of the other species here described from the same locality.

Locality and position: Same as last. Professor B. F. Mudge.

Tertiary species.

UNIO LEANUS, (MEEK.)

Shell attaining a medium size or larger, rather thin; longitudinally ovate, being somewhat less than twice as long as high, with the widest (highest) point in advance of the middle, rather distinctly convex; anterior side wider than the other, and regularly rounded; posterior margin more narrowly rounded, or sometimes obliquely subtruncate above; basal outline forming a broad, semiovate curve, with the most prominent part in advance of the middle; beaks moderately depressed and placed between one-third and one-fourth the length of the valves from the anterior margin; surface smooth or only showing marks of growth; hinge strong, cardinal teeth prominent, and leaving in internal casts a very profound impression, ranging vertically just behind the anterior muscular scar; lateral teeth long and straight; two in the left and one in the right valve.

Length, 3.80 inches; height, 2.20 inches; convexity, 1.40 inches.

This will be readily distinguished from that I have provisionally referred to *U. tellinoides*, H., by its proportionally longer and more convex valves, stouter hinge, and particularly by having larger, thicker, and more prominent cardinal teeth, ranging vertically, instead of very obliquely forward and downward. The specific name is given in honor of Dr. Isaac Lea, of Philadelphia.

Locality and position: Church Buttes, Wyoming Territory; miocene tertiary, in a rather coarse, greenish grit.

UNIO WASHAKIENSIS, (MEEK.)

Shell scarcely attaining a medium size; thin, depressed, rather compressed, longitudinally subovate; anterior side short, rounded; posterior side long, with a narrowly-rounded or sometimes faintly subtruncated extremity, the most prominent point being below the middle, while above this there is usually an oblique slope from the posterior extremity of the hinge; basal margin, forming a broad, semi-elliptic or semi-ovate curve, in the latter case the most prominent part being a little in advance of the middle; dorsal or hinge margin straight from the beaks to the upper slope of the posterior margin; beaks depressed nearly to the dorsal margin, rather regularly convex, but not ventricose, and placed about one-fourth the length of the valves from the anterior extremity; umbonal slopes moderately and evenly convex; surface smooth, or only showing more or less distinct marks of growth, excepting near the immediate points of the beaks, where well-preserved specimens show traces of minute, regular, longitudinal wrinkles, which terminate posteriorly at two faint, oblique, obsolescent, linear ridges; hinge, slender; cardinal teeth small, oblique, and apparently consisting of one in the right and two in the left valve; lateral teeth straight, rather long, two in the left, and one or two in the right valve.

Length of a large specimen, 2.37 inches; height, 1.26 inches; convexity, 0.72 inch.

This species is related to *U. priscus*, M. & H., with which it agrees nearly in form and surface characters. It is constantly smaller, however, and distinctly thinner, while its hinge is weaker and its cardinal teeth smaller and much more oblique. The wrinkles on its beaks, and the two oblique linear ridges on their posterior dorsal sides, are similar to those on *U. priscus*, excepting that they are less distinctly defined and occupy a much smaller space only near the points, instead of the whole surface of the umbones, being in fact so obscure and so near the points of the beaks as to be readily overlooked and entirely obsolete in most cases.

It will be distinguished from *U. Haydeni* mainly by its constantly more depressed and more elongated form. Its stratigraphical position is also, according to Dr. Hayden's observations, one thousand to two thousand feet lower in the series than that of *U. Haydeni*.

Locality and position: Washakie, Wyoming; also on Henry's Fork and on Green River, Wyoming Territory, at all of which places it is associated with *Viviporus paludinæformis* (=*Turbo paludinæformis* Hall) and *Goniobasis nodulifera* (=*Cerithium nodulosum*, Hall, not *G. nodulosa*, Lea.)

CORBICULA? FRACTA, (MEEK.)

Shell attaining a rather large size, longitudinally ovate, wider (higher) anteriorly, compressed, very thin and fragile; anterior margin rounded; pallial margin semiovate in outline; posterior margin narrower than the other, and subtruncate; dorsal outline sloping gradually, with slight convexity behind the beaks, and more abruptly in front; beaks rather depressed, oblique, and placed about one-third the length of the valves from the anterior extremity; surface only showing very obscure lines and somewhat stronger ridges of growth.

Length, 2.24 inches; height at the beaks, 1.48 inches; convexity, apparently about 0.40 inch.

The specimens of this species are all more or less flattened by accidental compression, but show the outline and surface characters perfectly, even to remains of the thin epidermis. With considerable difficulty I have succeeded in clearing away the matrix so far as to see that the hinge margin is comparatively strong for so thin a shell. It shows apparently three diverging cardinal teeth in each valve, and a linear anterior lateral tooth extending parallel to the anterior margin, while the posterior lateral teeth are somewhat remote from the cardinal, and rather elongated. On these posterior lateral teeth I have seen fine transverse striæ, which doubtless also exist on the anterior lateral, though I have not seen a specimen in a condition to show them.

Internal casts show the anterior muscular impression to be ovate, and the posterior broader, or more nearly circular, while the pallial line shows a shallow, rounded sinus, forming less than a semicircle.

Locality and position: Hallville coal mines, just above a bed of coal, in a black, argillaceous, rather hard rock, that may be shaly at some places.

CORBICULA? CRASSATELLIFORMIS, (MEEK.)

Shell attaining about a medium size, longitudinally ovate-subtrigonal compressed, very thin and fragile; anterior side rounded; pallial margin forming a semiovate curve, being more prominent anteriorly than behind; posterior side longer than the other, but much narrower, being very narrowly truncated at the immediate extremity; dorsal margin forming a long straight slope behind the beaks, and sloping more abruptly in front; beaks rather depressed, oblique, and located rather more than one-third the length of the valves from the anterior margin; posterior umbonal slopes showing some tendency to form a very slight prominence from the beaks toward the posterior basal extremity. Surface marked with fine lines, and a few irregular, stronger ridges and furrows of growth. Hinge not well made out.

Length, 0.95 inch; height, 0.60 inch; convexity, about 0.20 inch.

This form will be distinguished from the last, not only by its much smaller size, but by its more trigonal outline (caused mainly by the greater obliquity and straightness of its posterior dorsal slope), the greater prominence of its post-umbonal slopes, and its proportionally stronger ridges of growth. I have not seen its pallial line and know little of its hinge, though some of the specimens seem to show indications of three diverging cardinal teeth, as in the last. Like that species, it is a very thin, fragile shell.

In form and general appearance, this shell is much like *Cyrena* (*Corbicula*) *angustata*, Deshayes (An. Saus. Vert. Bassin de Paris, 1, p. 508, Pl. XXXVII, Figs. 9, 10, 11 et 12), but it not only attains a larger size, but differs in being more attenuated posteriorly, and more distinctly truncated at the immediate extremity of the narrowed posterior end.

Both this and the last-described species very nearly resemble some of the depressed, elongated species of *Crassatella*, in outline, and belong to Deshayes' section "oblongues transverses" of *Cyrena*, which includes some very thin species from the Paris Basin.

It is a curious fact, that at the same time these forms differ so very materially in form from the existing typical species of *Corbicula*, they have the lateral teeth of the hinge, in most cases, like those of that group, often even to the fine transverse striæ, instead of like those of the true Cyrenas. As Deshayes has remarked, the fossil species show gradations in form and hinge characters, that seem to indicate that those groups can scarcely be regarded as forming distinct genera, although it may be convenient to distinguish them subgenerically. There would still, however, apparently be as good reasons for forming for these longitudinally-ovate or subtrigonal, very thin shells, with hinge teeth more like those of *Corbicula*, a third subgeneric section. If so, I would propose for this group the name *Leptesthes*, with the first of the foregoing species as its type.

Locality and position: Same as last.

GONIOBASIS CHYSALLIS, (MEEK.)

Shell generally almost cylindrical below the middle, but more abruptly tapering above; volutions six or seven, flattened, with the upper margin thickened, last one not angular, and scarcely larger than the next above it; suture well defined. Surface ornamented by distinct vertical costæ, often ranging nearly in the same line all the way up the spire; these are partly interrupted by an effort to form three, or rarely four, obscure revolving lines or ridges, the upper of which is larger and more prominent than the others, which character, with the slightly enlarged upper ends of the vertical costæ, causes the thickened appearance of the upper margins of the volutions; several other slender and more distinct revolving lines also occur on the under side of the last turn. Aperture somewhat rhombic-ovate.

Length, about .60 inch; breadth, .18 inch.

I have seen no well-preserved specimens of this shell, but its peculiar form and the thickened character of the upper margins of its volutions distinguish it readily, even in very imperfect examples, from all of the other known species of this region. I had long back referred it, with much doubt, to *Goniobasis tenera*, Hall, (sp.,) (not Anthony;) but as the later collections brought from Utah and Wyoming contain a great number of another, but clearly distinct species, that agrees more nearly with Professor Hall's figure, both in form and the number of revolving lines on each volution, I am led to think that he must have had the latter species before him when he described his *G. tenera*. The fact, too, that it occurs in vastly greater numbers than the form under consideration, seems to sustain this conclusion.

Locality and positien: Bear River, near Sulphur Creek, Utah; Lower tertiary.

GONIOBASIS NODULIFERA, (MEEK.)

Cerithium nodulosum, Hall, 1845. Frémont's Roport Explorations, p. 309, Pl. III, Figs. 11 and 12. (Not *Goniobasis nodulosa*, Lea, 1841.)

Shell attaining a rather large size, elongate-conical; spire much produced; volutions seven or eight, convex, and increasing gradually and regularly in size; last one not larger in proportion than the others, and rounded; suture well defined and sometimes presenting a slightly banded appearance; aperture ovate; outer lip very strongly sinuous above the middle, and prominent below it. Surface ornamented with rather distinct lines of growth, that arch strongly parallel to the margins of the lip, and are crossed on the lower part of the last turn by from three or four to about six distinct, raised revolving lines, and near the middle, especially on those of the spire, by a small nodular carina or ridge.

Length of a large specimen, about 1.40 inches; breadth of same, 0.46 inch. Angle of spire regular, with a divergence of 18 to 20 degrees.

The surface markings of this shell, excepting sometimes the lines on the lower part of the last turn, are not seen on internal casts; while on the exterior, the revolving, slightly-nodular ridge is often obsolete on the last turn, and apparently sometimes nearly or quite so on some of those above. The revolving lines of the under side of the last volution are strongly defined, and it seems to be the upper one of these, continued upon those of the spire, just above the suture, that gives it the banded appearance. In some instances a few smaller revolving lines are seen farther up on the last turn, and even continued upon the lower half of the exposed part of some of those of the spire. Where the nodular ridge is most distinctly developed, the surface of the volutions above it is sometimes slightly concave.

Professor Hall's figures, especially his Fig. 12 of *Cerithium nodulosum*, represent the suture as being more oblique than in our specimens, but this is probably due to lateral compression. None of his figures show the strongly-arched lines of growth, nor more than one of the revolving lines on the lower part of the last turn. Both are mentioned, however, in his description. The arching character of the lines of growth is a distinctly-marked feature in this shell.

As the name *nodulosa* had been used by Dr. Lea for a species now included in the genus *Goniobasis*, it becomes necessary to find a new name for the shell under consideration, in placing it in that genus, consequently I have called it *G. nodulifera*.

Locality and position: Colonel Frémont's specimens of this species, according to his observations, came from latitude 41°30′; longitude 111° where they were found in a yellowish-gray oolitic limestone. Dr. Hayden's collections of it came from a locality a short distance farther to the southeast. They are in a yellowish-gray limestone, that sometimes shows a few oolitic grains. Dr. E. Palmer brought specimens of it from White River, still farther southeast in Colorado, in a yellowish, distinctly oolitic matrix. Lower tertiary.

BYTHINELLA GREGARIA, MEEK.

Shell small, conoid-subovate, spire rather elevated; volutions five, rounded, or very convex; suture strongly impressed; aperture ovate, or slightly longer than wide, with the upper extremity subangular, and the lower rounded; inner lip not reflected, and leaving by its side a very small umbilical impression that seems not to perforate the axis. Surface smooth, or only showing, under a strong magnifier, very minute lines of growth.

Length, 0.15 inch; breadth, 0.08 inch; length of aperture, 0.06 inch; breadth of aperture, scarcely 0.04 inch.

This little shell so nearly resembles, in form and proportions, the figures of *Bythinella tenuipes*, of Couper, that it is with some hesitation I have concluded to regard it as a distinct species. As that shell, however, is described as having its suture "slightly impressed," and as being "sub-umbilicated," while that under consideration has its suture *very deep*, and could not be properly described as even *sub*-umbilicated, I do not feel warranted in referring our tertiary form to the existing species

Of course we have no certain means of determining whether we ought not to call this shell *Amnicola gregaria*, or *Pomatiopsis gregaria*, instead of referring it to *Bythinella*, the distinctions between these groups being mainly based on characters not apparent in the shell. The fact, however, that it is found in vast numbers associated with a small *Planorbis*, and millions of the carapace-valves of a minute *Cypris*, would seem to indicate that it was aquatic in its habits, like *Bythinella* and *Amnicola*. It is true, terrestrial shells are often swept by streams into lakes, and deposited along with those of aquatic species; but it is exceedingly improbable that millions of so small a terrestrial shell as this would have been deposited all together, so as almost to form an entire bed of limestone, especially without some other terrestrial types.

Locality and position:: Pacific Springs. Tertiary.

II.—ON THE TERTIARY COALS OF THE WEST.

BY JAS. T. HODGE, GEOLOGIST.

The occurrence of coal in the Rocky Mountains was observed and reported on by most of the early explorers on the different routes they traversed across the continent. Little importance, however, was attached to these discoveries, and, as the coal-beds were seen only in their outcrop, little knowledge was acquired of their real character. It was understood that they belonged, not to the true coal formation, but either to the lower tertiary or upper cretaceous, and the coal was consequently classed among the lignites or brown coals, and generally considered to be far inferior in quality to the genuine coals of the Eastern and Middle States. As the country began to be settled, the scarcity of timber soon caused these deposits of fuel to be looked up, and mines of coal to be opened and worked in Utah and in Colorado. The construction of the Union Pacific and Central Pacific Railroads created a still greater demand for fuel for the supply of their locomotives, and new mines were opened along the line of the former road in Wyoming Territory, which, with those worked on the eastern border of Utah, near the same road, supply both these long lines of road with all the coal they require. No mines have been found near the Central Pacific Railroad, either in Utah, Nevada, or California, so that this road is wholly dependent for fuel upon the coals brought to it from the Union Pacific. Though it is scarcely three years since these coal-mines began to be developed, they have already produced large quantities of coal, and several among them have the appearance of thriving collieries, well furnished with powerful machinery for pumping and hoisting, and all the appliances of first-class establishments.

In Colorado, mines were opened along the eastern base of the Rocky Mountains about eight years since, and a number of them have been worked to a moderate extent from that time, supplying Denver and the settlements below the mountains. The coal was found very serviceable for domestic purposes, but was deficient in caloric quantities, such as are required for founderies and other metallurgical works. The writer in 1863 found the blacksmiths for the most part unable to produce a welding heat with the coal in their forges, and coke was brought from Kansas for a foundery at Black Hawk at an expense of $160 per ton. The coal-mines were then esteemed of very little value. The opening of the Kansas Pacific Railroad to Denver, of the Denver Pacific to Cheyenne, and of the Colorado Central from Denver to Golden City, with the prospect of its extension in another year to the mining towns in the mountains, has greatly added to the importance of these mines, and led to arrangements for working them upon a large scale. In September and October last the writer again examined them, and also visited all the coal-mines of importance in Wyoming and in Utah near the Union Pacific road, and the following are some of the results of his investigations and of the analyses he has made of the coals he has collected·

All these coal-mines are found in a series of sandstones and fire-clay, probably of lower tertiary age. No limestones occur with these strata, and black slate is met with in small quantity only. The sandstones are generally somewhat friable in texture, and are often exposed in bold cliffs, the faces of which have weathered in very irregular shapes, and frequently present deep holes and cavernous depressions. Its color is from a light-yellowish to reddish brown, and sometimes gray. In places it is sufficiently sound and firm to make a good building stone. The fossils it contains are chiefly leaves of deciduous trees. No ferns and other fossil plants are found in the formation like those common to the true coal-measures. The black slates forming the roof of a coal-bed at one locality in Wyoming Territory are found filled with fossil Unios, which, as the writer is informed by Dr. J. S. Newberry, are probably an undescribed species. Fire-clay is perhaps the predominant material of the formation. It occurs in beds of great thickness, especially in Colorado, and at Golden City it is manufactured into fire-bricks of excellent quality. Clay iron-stone is occasionally interstratified with the clays and black shales, and in Boulder County, Colorado, the summits and sides of some of the hills near the coal-mines are partially covered with masses of brown iron ore, that have the appearance of solid ledges, but which were no doubt collections of clay iron-stone, left behind when the lighter materials of the strata containing them were removed, and converted subsequently by atmospheric agency into those brown hydrates.

The coal-beds are often of great size, the largest now worked being twenty-six or twenty-seven feet thick. This is on Bear River, on the eastern border of Utah. For the most part they are remarkably free from impurities, it being not rare to see a face of eight or even ten feet of clean coal of brilliant luster, perfectly sound and solid in the mine, without a particle of slate or any visible foreign matter that would injure it. Iron pyrites, however, may generally be detected in small flakes and thin disks, but very rarely in sufficient quantity to be injurious. Mineral resin is a common ingredient of the Colorado coals, and was met with at one of the mines only on the Union Pacific Railroad, that at Carbon. The beds lie at an angle with the horizon; some are vertical, none were observed level.

All the coals tend to crumble soon after being exposed to the weather; but when protected they remain a long time unchanged, as is shown by a large lump in the possession of the writer, which he obtained at a mine in Boulder County, Colorado, in 1863, and which is still sound. This tendency to crumble is the cause of great waste at the mines—all the greater that these tertiary coals can scarcely ever be made to melt and agglutinate into a firm coke. With rare exceptions, when submitted to the coking process, they retain their form or crumble into a dry powder. As seen by their analysis they all contain water in their composition, and this is very slowly given up even at the boiling temperature. Its pressure necessarily detracts from the calorific power of the coals, not merely by reason of the water taking the place of so much carbon, but by the consumption of more to produce the heat required to expel this water. Hence it is difficult to obtain a strong, concentrated heat, such as is needed for welding iron in the forge-fire, and it is only by particular care and skill that the blacksmiths have generally succeeded in making it answer their purposes. At the machine shops of the Union Pacific Railroad it is not yet admitted as a substitute for eastern bituminous coals, though some of these are brought from Pennsylvania mines, about two thousand miles distant, and the very best of the Rocky Mountain coals are obtained directly on the line of the railroad. As a fuel for locomotives and for domestic purposes, including cooking as well as warming, the coal in general answers very well. It kindles and burns freely, making a bright fire, with a yellow blaze and comparatively little smoke; the odor of this is not so strong or disagreeable as that of the bituminous coals, and somewhat resembles the smell of burning peat. The smoke is not always dark and thick, but is sometimes of a light gray color. The ashes are remarkably light and bulky. The engineers of the locomotives find that some varieties crumble more than others in the fire, and sift through the grate bars; these require closer screens at the top of the smoke-stacks. They endeavor to obtain the coal as freshly mined as possible on account of its sounder condition. Clinkers sometimes form sufficiently to be troublesome when the coals are obtained from those mines that contain seams of slate. There have been a few cases of combustion of refuse heaps of coal, supposed to have occurred spontaneously. The presence of iron pyrites in coals so easy to crumble and ignite as these cannot fail to suggest this danger, and the importance of guarding all heaps of it from becoming wet. It is not unusual in the Rocky Mountain region to meet among the strata of sandstones beds of ashes, which are evidently the ruins of coal-beds, some of which are of large size. The writer has seen many such in the banks of the upper part of the Missouri River.

The geological position of these coals, together with the considerable proportion of water in their composition, places them in the class of brown coals or lignites, which are for the most part distinguished by their fibrous structure and close resemblance to the wood from which they are derived. The *braunkohle* of the tertiary formations of Saxony and Brandenburg, when dug and stacked in the fields, looks more like brown logs of wood than like mineral coal. Other varieties are met with in various conditions of change, and among them some that closely resemble the ordinary bituminous coals in their compact texture, brilliant luster, and black color, both of the coal and of its powder, thus differing entirely in appearance from the brown coals or lignites that give a name to the class. This is the general character of the coals of the Rocky Mountains, and their composition shows they are far superior in quality to what the name of the class would indicate. Indeed they appear to be better than the best of the foreign coals of their own variety, and, as they present a wonderful degree of uniformity over extensive territories, it seems they are really entitled to an appropriate name, that should distinguish them, not merely from the common bituminous coals, but from the other lignites also, to which they bear still less resemblance.

The European lignite deposits are of very limited area, scattered here and there through Prussia, France, Great Britain, &c., and in these small basins the composition of the fuel is very variable. In the Prussian provinces above named its value is rated at only one-third that of the genuine coals; while in the north of Ireland it is considered to be worth two-thirds as much as the bituminous coals. The weight of the ash in the published analyses for the most part exceeds four per cent., and ranges from this to twenty or thirty per cent., very rarely exceeding forty per cent. The composition of the American varieties, so far as found by the writer, is contained in the following table, which also gives the localities of the principal mines worked and the thickness of the beds. The water was determined by drying the coarsely-pulverized coal in an oil bath below the temperature of boiling oil and above that of boiling water, continuing the drying for several hours till the coal ceased to lose weight. The fixed carbon in all these analyses is uncertain in quantity, as its amount varies through a few per cent. according to the greater or less heat employed in expelling the volatile matters.

ANALYSES OF COALS FROM THE ROCKY MOUNTAINS.

Locality.	Miles from Cheyenne.	Thickness of bed, feet.	Specific gravity.	Water.	Ash.	Volatile.	Fixed carbon.	Description.
Golden City, C. T., 56 feet below surface.	110 S.	6 to 10	1.32	13.43	3.85	37.15	45.57	Gray ash.
Golden City, C. T., north end of 100 feet level.	....	6 to 10	1.354	13.67	4.00	34.75	47.58	
Do	....	6 to 10	......	13.10	3.70	......	......	
Golden City. C. T., south end of 100 feet level.	....	6 to 10	......	12.70	4.10	......	......	
Murphy's, Ralston Creek, C. T.	105 S.	14 to 16	1.345	13.83	5.85	35.88	44.44	Orange-colored ash.
Do	....	....	......	13.70	5.80	......	......	
Do	....	....	......	13.90	4.30	......	......	
Marshall's, Boulder Co., C. T.	96 S.	10	1.33	12.00	5.20	33.08	49.72	Gray ash; light, bulky.
Briggs's, Boulder Co., C. T.	84 S.	13	1.27	14.80	3.40	34.50	47.30	Orange-colored ash.
Baker's, Boulder Co., C. T	86 S.	4½	1.32	15.00	3.85	30.50	50.65	Olive-brown ash; coal hard and tough.
Carbon, W. T.	140 W.	7	1.33	6.80	8.00	35.48	49.72	Light-gray ash; nearly white.
Hallville, W. T., upper bed	282 W.	6	1.32	12.12	3.76	29.75	54.37	Gray ash; smoke whitish.
Hallville, W. T., lower bed	....	3	1.32	13.26	4.87	29.46	52.41	Yellowish-gray ash.
Van Dyke, W. T	313 W.	4½	1.27	8.12	2.00	36.65	53.23	Light-gray ash; these coals make coke.
Rock Springs, W. T	315 W.	9½	1.29	7.00	1.73	36.81	54.46	
Evanston, U. T	442 W.	26	1.30	8.58	6.30	35.22	49.90	
Crissman's, Coalville, U. T	480 W.	12	1.32	10.66	3.11	38.23	48.00	
Monte Diablo, Cal	....	....	......	3.28	4.71	47.05	44.90	By W. P. Blake, January, 1867.

Texture frequently very apparent; specific gravity about 1.2. At the temperature of boiling water they commonly lose about 3 per cent. In the analyses given the water thus obtained goes with the volatile matters in the second column. They do not generally melt by heat, but some of them soften sufficiently for the particles to adhere together, and some become fluid-like oils, at a moderate elevation of temperature. These last seem to belong altogether to fresh-water limestone formations, and to be nearly related to the petroleum found in the same formations.

Locality.	Ash.	Volatile.	Carbon.	Description.
Utweiler, right bank of the Rhine.	0.9	31.8	67.3	Water, 5 per cent.; compact, black, shining, specific gravity, 1.208.
Germany	4.6	52.5	42.9	Dull, brownish black; powder, same; compact, ash-brick color.
Edon, Charente	11.0	50.0	39.0	Shining black; contains resin; compact, with thin, jet-like layers.
St. Lon, Lower Pyrenees	5.6	46.0	48.4	Dull black; fracture, smooth and dull.
Enfant Dort, mouths of the Rhone	3.9	46.8	49.3	Black, with irregular, shining fracture.
Minerve L'Aude	10.0	57.4	32.6	Compact; brilliant black color; irregular fracture; powder, brownish black; yields coke.
Dauphin, Lower Alps	7.4	49.0	43.6	Compact; black, greasy luster; powder, clear brown; used by blacksmiths.

DESCRIPTION OF LOCALITIES.

Colorado.—Coal has been found in Colorado both on the east and west sides of the Platte River; but the only mines of importance are near the eastern foot of the easternmost or Blue Hills range of the mountains. The formation to which they belong is a series of sandstones and fire-clay, probably of lower tertiary age, which ranges north and south, and along its western margin is found uptilted in a vertical position, and sometimes dipping toward the metamorphic rocks that make up the steep mountain slope not half a mile distant. Farther away from the mountains the inclination is eastward, and so gentle that the coal strata overspread large tracts of country. The formation follows the range of the mountains north and south to an undetermined extent, and coal is met with in it for more than a hundred miles from Denver in each direction; but the only mines of value, excepting a few to the south, are at Golden City, fifteen miles west from Denver, and thence north for ten to fifteen miles into Boulder County, along the banks of the creeks that descend from the mountains eastward toward the Platte.

Golden City.—The first discoveries of coal at this place were several small and nearly vertical beds near together in the steep bank of Clear Creek, about half a mile below where it passes out from the mountains. These were followed but a short distance under the bank toward the south, when the extension of one of the beds in this direction was opened at the summit of the ridge, a quarter of a mile from the creek. The bed was here found so large—from ten to fourteen feet thick—that the lower workings were abandoned, and a vertical shaft was sunk on the hill, one hundred feet deep in the coal bed, and levels have been driven north and south from the bottom, and also fifty-six feet below the surface. The bed proved to be very irregular in thickness, sometimes pinching in to a few inches and then expanding to eight or ten feet. Its average thickness is not probably more than five feet. A small steam-engine is used for pumping and hoisting. Little water, however, is encountered. A cross cut from the bottom, driven seventy feet east, penetrated the following strata: clay, 4 feet thick; sandstone, 4; coal, 2; sandstone, 12; clay, 3; sandstone, 7; clay, 8; black slate, 3; clay, 4; sandstone, 3; clay, 2; coal, 2; clay, 8; coal, 2; sandstone, 6. The last stratum is probably the extension below of a heavy ledge of sandstone that forms the crest of the ridge. The clay is all fire-clay, of pretty uniform and excellent quality, very similar in appearance to that of the true coal-measures. It seems to be the prevailing material of the formation, and is used for the manufacture of fire-brick in an extensive manufactory at the base of the hill. The coal mine has been worked only to the moderate extent of about ten tons a day, for the supply chiefly of the local demand. The appearance of the coal itself—of a dull black without the bright luster common to the coals from the other mines—has operated unfavorably to its reputation in the Denver market, though no inferiority of quality is indicated by the analyses. It is obtained, too, in pieces of very irregular shape, quite unlike the handsome rectangular blocks of the other coals. Like them, however, it is almost entirely free from slate and iron pyrites. Resin occurs in it in scattered particles and bunches more abundantly than in the coals of the other mines. It may, perhaps, prove a better coal for gas than the other mines afford, which will soon be ascertained, if it has not been already, at the new gas works at Denver. The locality is very favorably situated for supplying the mining towns in the mountains with fuel, so soon as the railroad now in progress up the gorge of Clear Creek reaches them. The pine woods there available have already been greatly thinned, and the question of the future supply of fuel would be a serious one but for the supplies promised by these mines below the mountains.

The range of the coal-belt to the north side of Clear Creek was traced by the writer, in October last, and a point selected for trial shafts on the hills half a mile from the creek. The line of these vertical beds is but poorly indicated on the surface, and may be easily missed. Faint streaks of coal-smut or blossom were in this instance followed to the depth of seventy feet in fire-clay before they led to solid coal. The bed was here found about ten feet thick. From this side of the creek the railroad will be most conveniently supplied.

The outcrop of coal has been detected at intervals between Golden City and Ralston Creek, five miles to the north, and the formation evidently continues through, but no mines are worked in the intervening tracts.

Ralston Creek.—Two large coal beds are opened in the banks of this stream, five miles north from Golden City, and about two miles below the foot of the mountain range. They lie in a vertical position, about twenty-five feet apart. The upper or western one has been followed under the south bank some thirty feet, and was found to be about nine feet thick of good coal. But the other bed, proving to be quite as good as to quality of the coal, and affording in actual working full fourteen feet free from slate and all foreign matters, it has been worked in preference. Other small beds have been met with farther up the stream; but these two are probably all of importance. The large bed is worked on both sides of the creek, and on the north side a large shaft was sunk the last season sixty feet deep in the coal, from the bottom of which levels are to be run north and south. The price paid for mining was $1 50 per ton—the coal run out by the miners, who found their own tools, powder, and lights. The timber required for stulls, &c., was provided by the owner from the mountains. Not so much of this is required in working a vertical bed as is needed in one inclined. But, on the other hand, the trouble, danger, and expense of working the former are essentially greater, and the amount of coal available over large areas materially less. In this case, estimating with allowance for waste, that the production should average twelve feet of coal, and that a cubic yard of this weighs two thousand pounds, the mine should afford, if worked to the depth of two hundred yards and a mile in length, about one million and fifty thousand tons. The quantity obtained, however, will depend very much upon the skill with which the work is conducted, and the freedom from accidents, especially fire, the danger of which has already been experienced. The coal appears very well, being of deep-black color with brilliant luster. It soon crumbles, however, on exposure, and the waste from fine coal in the mine has been so great that, if continued, a larger deduction would have to be made than that allowed in the above estimate. The coal has met with a ready sale at the mine at $4 per ton, and $10 at Denver, fourteen miles distant. The construction of the railroad to Golden City must so reduce the cost of transportation that Denver will hereafter be supplied at lower rates.

Half a mile south from Ralston Creek, towards Golden, coal was discovered some time ago directly on the range of the bed worked, of which it is no doubt the continuation. The exploration thus made developed a large bed with a gentle dip toward the mountains. Whenever this is opened again it will be a matter of interest to trace out the extent of this change of dip.

Leiden's.—The next opening in the coal-bed to the north is in a gap through the sandstone ridge about a mile and a half from Ralston Creek, and is known as Leiden's mine, from the name of the late owner, who with two other men lost their lives by entering the mine last September, when the air was foul in consequence of its having been left unworked. It continued for some time inaccessible, and smoke was issuing from the entrance, when the writer visited the place five days after the occurrence mentioned above. The locality is of interest as showing the continuity of the coal. The formation is easily traced northward from this point over a broad and highly-elevated open plateau, by the strata of sandstone projecting in vertical layers above the surface; and the coal can, without doubt, be found anywhere against the western edge of the strata, or in the depressions below the general level now occupied by ponds. The lands, however, are not likely to be soon occupied, the soil being filled and covered with small boulders from the mountains; still, by irrigation, a considerable portion of them may be made productive; and the fact that several ditches are already made across these tracts to the lower and better lands to the east shows that water is available even at their high levels. But the coal is more profitably obtained in the valleys of the creeks than in the elevated divides.

In the next valley crossed by the belt, that of Coal Creek, some seven miles from Ralston Creek, another opening is met with under the western edge of the same sandstone ridge. The mine, however, is not now worked, the owners finding it more convenient to develop their other property near South Boulder Creek, two or three miles over the next divide to the north.

Marshall's.—The mines in the valley of South Boulder Creek, known as Marshall's, are among the earliest worked in Colorado. They were in operation in 1863, and have continued without interruption to furnish coal to Denver twenty-two miles distant, and to the neighboring settlements. The locality is a little to the south of the creek, in the hills bordering a small branch about two miles below the foot of the mountains. As many as four beds of coal have here been opened, two of which may, however, prove to be the same. One of them—the highest in the series—is found just under the summit of the divide, dipping gently toward the southeast. It is known as the Dabney bed—is said to be nine feet thick, and when worked, furnished coal of a superior quality, especially for blacksmiths' use. At a lower level, and also lower in the formation, is found the main bed, which is worked to the thickness of ten feet, through the whole of which the coal is remarkably clean and free from slate and other impurities. It contains very little pyrites in their disks and some resin in small particles. In the mine the freshly-exposed face presents a beautifully brilliant appearance, and the coal is so found that a cubic block of it, said to weigh over three tons, was taken out for exhibition at the fair in Denver. It is used very generally by the blacksmiths, who have overcome the difficulty they formerly experienced in not being able to get up a welding heat with it. The mine is worked by two parallel headings, or levels, driven in from the north side of the hill, and rising a little up the slope of the bed. These extend about six hundred feet in, and rooms are worked on each side, but chiefly up the slope. In the other direction the bed passes under a meadow, when the coal will have to be worked and drained by means of vertical shafts. It is now mined for $1 25 per ton beside cost of props and keeping the track, &c., in good condition.

A third bed of coal three feet thick is found across the meadow just spoken of, in the hill to the east, not half a mile from the main bed. It dips eastwardly into the hill, and has been followed down the slope sixty or seventy feet, under a roof of fire-clay. This appears to lie between the Dabney and the main bed.

The fourth bed is not far from the small bed just described, being a little to the north of a line connecting it with the mine now worked. It differs from the others in lying in a vertical position; and it is not clear where its position is in the series. A shaft was sunk upon the bed some years ago to the depth of fifty feet, and the coal was raised by a horse-whim. The bed was seven feet thick.

A small blast furnace was built at this place in 1863 for the purpose of working the brown hematite iron ores found scattered about the hills in the vicinity. It ran but a short time, when the enterprise was abandoned. Though the coal mines were so conveniently near, no attempts were made to use the coal; but pine-wood charcoal from the mountains was employed as fuel. The iron made was of superior quality, and it is evident from the appearance of the cinder heap that the furnace, notwithstanding its diminutive size, must have worked well.

Wilson's.—From Marshall's north it is less than a mile over the plateau into the next depression, where the large coal-bed, easily traced by the outcrop of the sandstone ledge that overlies it, is again opened and worked. This place is known as Wilson's mine. The bed has been followed down the slope toward the south-southeast about two hundred feet, and the height of the excavation in the coal is from six to seven feet. Probably the whole is not taken out. The coal itself is the same in appearance as that obtained at Marshall's.

The continuation of the coal-bearing belt toward the north here appears to be interrupted, as no more mines are opened in this direction. The dip of the strata is with the slope of the surface toward the east, but somewhat steeper, so that the coal beds are carried under and disappear. It seems, however, that the dip must change and a sharp uprise to the east take place, followed again by a long gentle slope in the same direction; for the surface of the country appears to indicate this in the steepness of its short western slopes, and also the reappearance of large coal beds some thirteen miles northeast of the last mine described. These are found in the side of a steep hill that ranges along the east side of Coal Creek, the same stream noticed before as being crossed by the coal-bearing belt near the mountain range; and which below turns from an eastern to a northerly course.

Briggs's.—The most northern opening in these beds is that of the Messrs. Briggs. It is on the side of the hill facing the creek and follows the slope of the bed into the hill east-northeast, the inclination not being so steep but one can walk easily down. The length of the heading is about five hundred feet, and rooms have been worked to the right and left. No water has yet been encountered in quantity to be troublesome. The coal-bed is about thirteen feet thick, including in this a seam of slate a foot and three inches thick at three to three and a half feet above the floor. The coal presents a handsome appearance, being of a bright glistening black, and coming out in sound blocks of rectangular fracture. It has been mined for the Denver market, twenty-three miles distant; and arrangements are now in progress for extending a branch of the Denver Pacific Railroad to the mine.

Baker's.—The Baker or Douglass coal-bed is three and a half miles farther up the creek, toward the south, and on the same side of it with the Briggs bed. It lies about two hundred feet lower down than this in the formation, as the extension of the latter is found at this greater elevation near by. The mine was originally opened in the bank of the creek, and this being an inconvenient place to work it, an inclined shaft was started on the bench above and carried down through the overlying fire-clays and sandstone to the coal, when it followed the regular slope of the bed. A steam-engine is employed to hoist the coal and the water. The bed is four and a half to five feet thick, dips east into the hill, and produces a coal very different in appearance from that of the other mines. A part of it is a dull jet-black, hard and brittle, breaking in cuboidal fragments; and streaks of this cannel-like character are seen in the more brilliant varieties that are also found. Iron pyrites in extremely thin disks and resin also are noticed in the coal.

Two or three other small beds of coal appear in the bank of the creek, and in the slates or shales over them are courses of kidney iron ore that may possibly prove sufficient for the support of a blast furnace.

Other coal-beds will doubtless be opened in this region, and also farther back toward the other mines. The only one discovered the last season was by Mr. Davidson, in exploring the strata near the highest elevation of the country, probably far above the great coal-bed. It proved to be a bed about three and a half feet thick.

Wyoming Territory.—Although the coal-belt of Colorado extends north into Wyoming Territory, and indications of coal have been found near the line of the Union Pacific Railroad, it has nowhere been found productive of good coal to the east of the Black Hills. Beyond this range of mountains, in the Laramie Valley, the same formation is again met with, and valuable mines of coal are worked at intervals near the road even to Salt Lake Valley.

Carbon.—The first of these is at Carbon, a station one hundred and forty miles by the road from Cheyenne, which is at the east foot of the Black Hills. Here, by the side of the track, a large shaft has been sunk seventy feet deep down to a coal bed seven feet thick; a steam-engine for pumping and hoisting is in operation, and all the appliances are provided in the way of good machinery and buildings of a first-class colliery. A considerable proportion of the coal used on the railroad is here obtained; and it is transported for sale to Omaha, five hundred and fifty-six miles by railroad, and to Denver, two hundred and fifty miles. The coal is in fair repute, though it makes some clinker, and the analysis shows it has more mineral impurity than the other coals. This comes in part from small seams of slate in the bed, and also from a coating of a white powder observed in the seams of the coal, which proves to be carbonate with a little sulphate of lime. If it contains more ash, it is, on the other hand, comparatively free from water, showing the least percentage of this of any coal analyzed. The smoke of this coal is black, like that of the bituminous coals.

Hallville.—The next mining establishment is at Hallville, one hundred and forty-two miles farther west. Several coal-beds (probably four) are here found in a hill about three hundred yards south from the railroad, and a side track leads from this to the mine. The main bed of coal is from five and a half to six feet thick; and below it is another bed three feet thick, which in one place comes within a foot of it, and in others is separated from it by several feet of slates. Other irregularities of stratification are noticed in the main coal-bed itself, which near the entrance of the mine has in the lower half some small seams of slate, and near the roof a layer of "bony," inferior coal, eight inches thick, none of which are found in the inner or extreme part of the workings. The coal itself is hard and solid, and burns with a white smoke and little odor. The mine is worked without trouble from water, and the coal is drawn out on an iron track by mules.

The black slate roof of the main bed abounds in fossil remains of fresh-water shells—unios of undescribed species. In the inner part of the mine, when the roof has been allowed to come down, many tons of these slates might be collected charged with the shells, still white, and often both valves preserved side by side. The brown sandstones interstratified with the coal-beds contain stems of trees converted into the same rock, and impressions of the leaves—all, however, very obscure.

Van Dyke.—The next coal mine along the road is known as the Van Dyke, thirty miles farther west. This is in a hill on the north side of the railroad track, and so conveniently near to it that the coal is discharged by a chute from the mine directly into the cars. The bed is four and a half feet thick, entirely free from any admixture of foreign substance, except a trifling amount of iron pyrites in thin flakes in the seams, and dips gently to the northwest into the dry, barren hill in which it is found. The roof over it is remarkably smooth and sound, so that all the coal can be taken out clean, and comparatively few props are required for supporting it. This is an important consideration in a country so barren of trees as this Bitter Creek region. No water is met with in the mine, and the bed can apparently be followed over an extensive range northeast and west without encountering any. The mine fronts upon the valley of Bitter Creek toward the south; and in the hills opposite it seems as if the same bed must again strike in.

The Van Dyke coal and that of Rock Springs, two miles beyond, have the best reputation of any of the Rocky Mountain coals, and this by their analysis seems to be well deserved. These were the only coals that afforded anything like coke by distillation; and they should give a more concentrated heat than any of the others, showing the best adaptation for metallurgical purposes.

Rock Springs.—The mines known by this name are two miles west from the Van Dyke bed, and one mile east from the station of the same name. The coal of this locality has been obtained chiefly from a dry, barren knoll of cavernous sandstone, about sixty feet high, situated about fifty rods southeast from the railroad, with which it is connected by a branch track. On the south side—away from the railroad—the knoll ends abruptly in vertical cliffs; and in these near the summit is the outcrop of the coal-bed, and the entrance to the mine. The slope of the strata is north-northwest, which carries the coal-bed under the main track of the railroad; and as the knoll is now almost exhausted of coal, arrangements have been made for working the bed close to the main road, where also is the village of miners' houses. The bed is about nine and one-half feet thick, but only about seven feet are worked; for within two feet of the top is a thin seam of slate, that, with the coal above it, makes a better roof than the dry and crumbling slates and sandstones above would make. The coal, like the Van Dyke, is very sound and clean, igniting readily and burning away entirely without crumbling in the fire. The smoke is black, like that of the bituminous coals. The mine is worked by contract—the miners riddling the coal in the mine, and delivering the lump coal only outside for $1 25 per ton. The workmen have evidently been left to their own discretion, without any regard to obtaining the greatest amount of coal the mine should afford.

The opening by the railroad track is a slope passing under Bitter Creek. This had not in October passed quite through the "rusty" coal into the sounder part of the bed. The mine has to be provided with a steam-engine for pumping and hoisting, and will no doubt be productive in large quantities of excellent coal.

This vicinity, like most of the Bitter Creek Valley, is deficient in good water; so that, for about sixty miles east from Green River, this has to be brought for the supply of the inhabitants and for the locomotives in cars specially provided for the purpose, and making what is called the water train. The cars, nine in number, have each two tanks about nine feet high and seven and one-half feet average diameter, all of which are connected by a large hose. Following the water-cars is a box car, in which is a locomotive-boiler and a large steam-pump. By means of this the water is pumped into the stationary tanks at the stations, and into the barrels, casks, tubs, and even kettles and cooking-stove boilers, with which the inhabitants near the stations run, on the arrival of the train three times a week, to receive their supplies of water, paying for it at the rate of twenty-five cents a barrel.

Utah—Evanston.—The station of this name on the Union Pacific Railroad is four hundred and forty-one miles from Cheyenne, or one hundred and twenty-six from Rock Springs. The mines are two miles northwest from the station across Bear River, in a hill on the north side of the fine, wide valley of this stream. Seen from the mines this valley presents the appearance of a beautiful plain stretching out about four miles to the hills on the opposite side. Were the regions less elevated and the winters less severe, this would be a most attractive site for a large settlement. Bear River is a swift stream of good water, well stocked with large brook trout. The Wahsatch Mountains, in view to the west, furnish pine timber from their extensive forests. Building stone of superior quality is quarried from the sandstone beds near the coal-mines, and clay-beds are worked for the manufacture of bricks at the foot of the hill.

A branch railroad has been constructed to the mines, and is used for the benefit of both the Union Pacific and the Central Pacific Railroads, the former being supplied with coal by the Wyoming Coal Company, and the latter by the Rocky Mountain Coal Company, whose mines adjoin each other in the same coal bed. This bed, which is nowhere exposed of its full thickness, is said to measure twenty-six or twenty-seven feet from the floor to the roof. It is evidently a bed of extraordinary size; but the workings are limited to the lower portion of it only, not more than eight or ten feet being taken out. This is for the sake of greater convenience in getting the coal now required and of economy in timber for props. It must be, however, at the probable sacrifice of all that is left, which is hardly likely ever to be recovered in good condition. The bed dips into the hill at an angle of about fifteen degrees with the horizon, becoming suddenly steeper at the lower end of the slope, which is already down over one thousand feet in the mine of the Wyoming Company. Horizontal levels as long as the slope are driven each way from it, and many rooms worked. Many small seams of slate are seen in the bed, which, not being easily separated from the coal, must considerably impair its value. This damage would be overlooked in analyzing specimens of the coal, which would always be selected free from the slate. Iron pyrites are more abundant than in the coals of other mines; and it is stated that spontaneous combustion of a waste heap has occurred, attributable, no doubt, to decomposition of the pyrites. The locomotive engineers complain that the coal does not burn up clean and clinkers; still it is used by blacksmiths, who manage to get up a welding heat with it. The arrangements for working the mines with powerful engines and machinery are those of extensive collieries, and the business is evidently bound to be large. The coal must be obtained in any desired quantity, and at the minimum of cost. The formation containing the coal beds is obviously of the same period with that to which the Colorado coals belong.

Coalville.—The Mormons have worked several coal mines at this village and in the neighborhood, sending the coal to Salt Lake City, about fifty miles distant by the old stage road, and more recently to Corinne, on the Central Pacific railroad. Coalville is five miles south from the Union Pacific Railroad at Echo Station, and this is thirty-four miles west from Evanston. At the village is Sprague's mine, which was not in operation last October; and two miles up a narrow valley to the northeast is Robinson's mine, and immediately above this Crissman's mine. All these are apparently on the same bed of coal. Higher up in the hills are two other small beds, not worked. Robinson's and Crissman's mines are both opened in the bottom of a ravine, and the former is supplied with a small steam-engine for hoisting the coal up the slope. The latter mine is entered by an adit level; and again farther up by a slope. The dip is to the northwest, and so gentle that a mule can haul a ton weight up the iron-covered track. The bed is from eleven and a half to thirteen feet thick, all solid coal. The roof is sandstone, and not very secure; so that nearly the upper half of the coal bed is left for safety, with the idea of some time taking it out. This makes a secure covering. Though the coal is very sound in the mine, and presents a handsome appearance after it is extracted, it soon crumbles on exposure to the air, and the railroad men do not speak well of it for locomotive use. It crumbles in the fire, and makes clinkers, that melt and stick to the bars. Blacksmiths, however, use it satisfactorily. It is mined for $1 25 per ton, and sells for $2 50 on the ground. The bed must extend under large areas, which have not yet been explored for it. Its dip, if continued, would carry it under the sandstone cliffs of Echo Cañon.

III.—THE ANCIENT LAKES OF WESTERN AMERICA:

THEIR DEPOSITS AND DRAINAGE.

By J. S. Newberry, LL. D.

The wonderful collections of fossil plants and animal remains brought by Dr. Hayden from the country bordering the Upper Missouri have been shown, by his observations and the researches of Mr. Meek, to have been derived from deposits made in extensive fresh-water lakes—lakes which once occupied much of the region lying immediately east of the Rocky Mountains, but which have now totally disappeared. The sediments that accumulated in the bottoms of these old lakes show that in the earliest periods of their history they contained salt water, at least that the sea had access to them, and their waters were more or less impregnated with salt, so as to be inhabited by oyster and other marine or estuary mollusks. In due time the continental elevation which brought all the country west of the Mississippi up out of the widespread cretaceous sea, raised these lake basins altogether above the sea level, and surrounded them with a broad expanse of dry land. Then ensued one of the most interesting chapters in the geological history of our continent, and one that, if fairly written out, could not fail to be read with pleasure by all intelligent persons. The details of this history are, however, in a great measure yet to be supplied, inasmuch as the great area of our western possessions is still but very partially explored, and it is certain that it forms a great treasure-house of geological knowledge, from which many generations will draw fresh and interesting material before its riches shall be exhausted.

The enlightened measures adopted by our Government for the exploration of the public domain, the organization and thorough equipment of the numerous surveying parties that have traversed the region west of the Mississippi within the last twenty years, together with the still more extensive explorations by private enterprise of our great mining districts, have resulted in giving us materials from which an outline sketch can now be made that may be accepted in all its essential particulars as accurate and worthy of confidence.

It has happened to me to be connected with three of the Government surveys to which I have referred, and to spend several years in traversing the great area lying between the Columbia River and the Gulf of Mexico. The observations which I have made on the geological structure of our Western Territories supplement in a somewhat remarkable way those made by Dr. Hayden, so that, taken together, our reports embody the results of a reconnoissance stretching over nearly the whole of our vast possessions west of the Mississippi.

Our knowledge of the geology of this region has also been largely increased by the no less important contributions of other explorers. Among those who deserve most honorable mention in this connection are Mr. George Gibbs, to whom we are indebted for most that we know of the geology of Washington Territory; to Professors W. P. Blake and Thomas Antisell; to Professor Whitney and the other members of the California geological survey; to Baron Richthofen, the lamented Rémond, Drs. Shiel, Wislizenus, and others.

The results obtained by the last, largest, and best-organized party which has been engaged in western explorations—that of Mr. Clarence King—have not yet been given to the public; but, from an examination of some of the materials which are to compose the reports of this expedition, I feel justified in saying that it will prove to be among the most important of all the series of explorations of which it forms part; and that the published results of this expedition will be not only an important contribution to science and our knowledge of our own country, but a high honor to those by whom the work has been performed, and to the Government, by which it was organized.

Without going into details or citing the facts or authorities on which our conclusions rest, I will in a few words give the generalities of the geological and topographical structure of that portion of our continent which includes the peculiar features that are to be more specially the subject of this paper.

It is known to most persons that the general character of the topography of the region west of the Mississippi has been given by three great lines of elevation which traverse our territory from north to south: the Rocky Mountain Belt, the Sierra Nevada, and the Coast Ranges. Of these the last is the most modern, and is composed, for the most part, of miocene tertiary rocks. It forms a raised margin along the western edge of the continent, and has produced that "iron-bound coast" described by all those who have navigated that portion of the Pacific which washes our shores.

Parallel with the Coast Mountains lies a narrow trough, which, in California, is traversed by the Sacramento and San Joachin Rivers, and portions of it have received their names. Farther north this trough is partially filled, and for some distance nearly obliterated by the encroachment of the neighboring mountain ranges, but in Oregon and Washington it reappears essentially the same in structure as farther south, and is here traversed by the Willamette and Cowlitz Rivers.

These two sections of this great valley have now free drainage to the Pacific, through the Golden Gate and the trough of the Columbia, both of which are channels cut by the drainage water through mountain barriers that formerly obstructed its flow, and produced an accumulation behind them that made these valleys inland lakes; the first of the series I am to describe of extensive fresh-water basins that formerly gave character to the surface of our Western Territory, and that have now almost all been drained away and disappeared.

East of the California Valley the Sierra Nevada lies, like a lofty mountain chain, reaching all the way from our northern to our southern boundary. The crest of the Sierra Nevada is so high and continuous that for one thousand miles it shows no passes less than five thousand feet above the sea, and yet at three points there are gateways opened in this wall, by which it may be passed but little above the sea level. These are the cañons of the Sacramento, (Pit River,) the Klamath, and the Columbia. All these are gorges cut through this great dam by the drainage of the interior of the continent. In the lapse of ages the cutting down of this barrier has progressed to such an extent as almost completely to empty the great water basins that once existed behind it, and leave the interior the arid waste that it is—the only real desert on the North American continent.

The Sierra Nevada is older than the Coast Mountains, and projected above the ocean, though not to its present altitude, previous to the tertiary and even cretaceous ages. This we learn from the fact that strata belonging to these formations cover its base, but reach only a few hundred feet up its flanks. The mass of the Sierra Nevada is composed of granitic rocks, associated with which are metamorphic slates, proved by the California survey to be of triassic and Jurassic age. These slates are traversed in many localities by veins of quartz, which are the repositories of the gold that has made California so famous among the mining districts of the world.

East of the Sierra Nevada we find a high and broad plateau, five hundred miles in width, and from four thousand to eight thousand feet in altitude, which stretches eastward to the base of the Rocky Mountains, and reaches southward far into Mexico. Of this interior elevated area the Sierra Nevada forms the western margin, on which it rises like a wall. It is evident that this mountain belt once formed the Pacific coast; and it would seem that then this lofty wall was raised upon the edge of the continent to defend it from the action of the ocean waves. In tracing the sinuous outline of the Sierra Nevada, it will be seen that its crest is crowned by a series of lofty volcanic cones, and that one of these is placed at each conspicuous angle in its line of bearing, so that it has the appearance of a gigantic fortification, of which each salient and reëntering angle is defended by a massive and lofty tower.

The central portion of the high table-lands to which I have referred was called by Frémont the "Great Basin," from the fact that it *is* a hydrographic basin, its waters having no outlet to the ocean. The northern part of this area is drained by the Columbia; the southern by the Colorado. Of these the Columbia makes its way into the ocean by the gorge it has cut in the Cascade Mountains, through which it flows nearly at the sea level; while the Colorado flows to the Gulf of California through a series of cañons, of which the most important is nearly one thousand miles in length, and from three thousand to six thousand feet in depth. In volume 6 of the Pacific Railroad Reports I have described a portion of the country drained by the Columbia, and have given the facts that lead me to assert that the gorge through which it passes the Cascade Mountains has been excavated by its waters; and that previous to the cutting down of this barrier these waters accumulated to form great fresh-water lakes, which left deposits at an elevation of more than two thousand feet above the present bed of the Columbia. Similar facts were observed in the country drained by the Klamath and Pit Rivers, and all pointed to the same conclusion.

In all this region I observed certain peculiarities of geological structure that have been remarked by most of those who have traversed the interval between the Sierra Nevada and the Rocky Mountains. In the northern and middle portions of the great table-lands the general surface is somewhat thickly set by short and isolated mountain ranges, which have been denominated the "Lost Mountains." These rise like islands above the level of the plain, and are generally composed of volcanic or metamorphic rocks. The spaces between these mountains are nearly level, desert surfaces, of which the underlying geological structure is often not easily observed. Toward the north and west, however, wherever we come upon the tributaries of the Columbia, the Klamath, or Pit Rivers, we find the plateaus more or less cut by these streams and their substructure revealed.

Here the underlying rocks are nearly horizontal, and consist of a variety of deposits, varying much in color and consistence. Some are coarse volcanic ash, with fragments of pumice and scoria. Others I have in my notes denominated "concrete," as they precisely resemble the old Roman cement and are composed of the same materials. In many localities these strata are as fine and white as chalk, and, though containing little or no carbonate of lime, they have been referred to as "chalk-beds" by most travelers who have visited this region. Specimens of this chalk-like material gave me my first hint of the true history of these deposits. These, collected on the head-waters of Pit River, the Klamath, the Des Chutes, Columbia, and elsewhere, were transmitted to Professor Bailey, then our most skilled microscopist, for examination. Almost the last work he did before his untimely death was to report to me the results of his observation on them. This report was as harmonious as it was unexpected. In every one of the chalk-like deposits to which I have referred he found *fresh-water diatomaceæ.*

From the stratification and horizontality of these deposits, I had been fully assured that they were thrown down from great bodies of water that filled the spaces separating the more elevated portions of the interior basin, and here I had evidence that this water was fresh. Since that time a vast amount of evidence has accumulated to confirm the general view then taken of the changes through which the surface of this portion of our continent has passed. From Southwestern Idaho and Eastern Oregon I have now received large collections of animal and vegetable fossils of great variety and interest. Of these the plants have been, for the most part, collected by Rev. Thomas Condon, of The Dalles, Oregon, who has exposed himself to great hardship and danger in his several expeditions to the localities in Eastern Oregon where these fossils are found. The plants obtained by Mr. Condon are apparently of miocene age, forming twenty to thirty species, nearly all new, and such as represent a forest growth as varied and luxuriant as can be now found on any portion of our continent.

The animal remains contained in these fresh-water deposits have come mostly from the banks of Castle Creek, in the Owyhee district, Idaho. The specimens I have received were sent me by Mr. J. M. Adams, of

Ruby City. They consist of bones of the mastodon, rhinoceros, horse, elk, and other large mammals, of which the species are probably in some cases new, in others identical with those obtained from the fresh-water tertiaries of the "bad lands" by Dr. Hayden. With these mammalian remains are a few bones of birds and great numbers of the bones and teeth of fishes. These last are cyprinoids allied to *Mylopharodon*, *Milocheilus*, &c., and some of the species attained a length of three feet or more. There are also in this collection large numbers of fresh-water shells of the genera *Unio*, *Corbicula*, *Melania*, and *Planorbis*. All these fossils show that at one period in the history of our continent, and that, geologically speaking, quite recent, the region under consideration was thickly set with lakes, some of which were of larger size and greater depth than the great fresh-water lakes which now lie upon our northern frontier. Between these lakes were areas of dry land covered with a luxuriant and beautiful vegetation, and inhabited by herds of elephants and other great mammals, such as could only inhabit a well-watered and fertile country. In the streams flowing into these lakes, and in the lakes themselves, were great numbers of fishes and mollusks of species which, like the others I have enumerated, have now disappeared. At that time, as now, the great lakes formed evaporating surfaces, which produced showers that vivified all their shores. Every year, however, saw something removed from the barriers over which their surplus water flowed to the sea, and, in the lapse of time, they were drained to the dregs. In the Klamath Lakes, and in San Francisco, San Pablo, and Suisun Bays, we have the last remnants of these great bodies of water; while the drainage of the Columbia lakes has been so complete that in some instances the streams which traverse their old basins have cut two thousand feet into the sediments which accumulated beneath their waters.

The history of this old lake country, as it is recorded in the alternations of strata which accumulated at the bottoms of its water basins, will be found to be full of interest. For while these strata furnish evidence that there were long intervals when peace and quiet prevailed over this region, and animal and vegetable life flourished as they now do nowhere on the continent, they also prove that this quiet was at times disturbed by the most violent volcanic eruptions, from a number of distinct centers of action, but especially from the great craters which crowned the summit of the Sierra Nevada. From these came showers of ashes which must have covered the land and filled the water so as to destroy immense numbers of the inhabitants of both. These ashes formed strata which were, in some instances, ten or twenty feet in thickness. At other times the volcanic action was still more intense, and floods of lava were poured out, which formed continuous sheets hundreds of miles in extent, penetrating far into the lake basins, and giving to their bottoms floors of solid basalt. When these cataclysms had passed, quiet was again restored, forests again covered the land, herds dotted its pastures, fishes peopled the waters, and fine sediments abounding in forms of life accumulated in new sheets above the strata of cooled lava. The banks of the Des Chutes River and Columbia afford splendid sections of these lake deposits, where the history I have so hastily sketched may be read as from an open book.

But it will be said that there are portions of the great central plateau which have not been drained in the manner I have described. For here are basins which have no outlets, and which still hold sheets of water of greater or less area, such as those of Pyramid Lake, Salt Lake, &c. The history of these basins is very different from that of those already mentioned, and not less interesting or easily read. By the complete drainage of the northern and southern thirds of the plateau through the channels of the Columbia and Colorado, the water surface of this great area was reduced to the tenth or hundredth part of the space it previously occupied. Hence the moisture suspended in the atmosphere was diminished in like degree, and the dry hot air, sweeping over the plains, licked up the water from the undrained lakes until they were reduced to their present dimensions. Now, as formerly, they receive the constant flow of the streams that drain into them from the mountains on the east and west. But the evaporation is so rapid that their dimensions are not only not increased thereby, but are steadily diminishing from year to year. Around many of these lakes, as Salt Lake, for example, just as around the margins of the old drained lakes, we can trace former shore lines and measure the depression of the water level. Many of these lakes of the Great Basin have been completely dried up by evaporation, and now their places are marked by alkaline plains or "salt flats." Others exist as lakes only during a portion of the year, and in the dry season are represented by sheets of glittering salt. Even those that remain as lakes are necessarily salt, as they are but great evaporating pans where the drainage from the mountains—which always contains a portion of saline matter—is concentrated by the sun and wind until it becomes a saturated solution and deposits its surplus salts upon the bottom.

The southern portion of the great central table-land—that which has been denominated the Colorado plateau—is almost without mountain barriers or local basins, and we therefore find upon it fewer traces of ancient lakes, though they are not entirely wanting. It is apparent, however, that this high plateau, which stretches away for several hundred miles west of the Rocky Mountains, was once a beautiful and fertile district. The Colorado draining then, as now, the western ranges of the Rocky Mountains, spread over the surface of this plateau, enriching and vivifying all parts of it. When it reached the western margin of the table-land, however, it poured over a precipice or slope five thousand feet in height, into the Gulf of California, which then reached several hundred miles farther north than now. In process of time the power developed by this stupendous fall cut away the rock beneath the flowing water, and formed that remarkable gorge to which I have already referred. This gorge is nearly one thousand miles in length and from three thousand to six thousand feet in depth, and is cut through all the series of sedimentary rocks from the tertiary to the granite, and has worn out the granite to a depth of from six hundred to eight hundred feet. Just in proportion as the Colorado deepened its channel, the region bordering it became more dry, until ultimately the drainage from the mountains passed through it, in what may be even termed underground channels, and contributed almost nothing to the moisture of the surrounding country. The reason why the walls of this cañon stand up in such awful precipices of thousands of feet is, that the perennial flow of the stream is derived in far distant mountains; almost no rain falls upon its banks, and when any portion of the bordering cliff has passed beyond the reach of the stream, it stands almost unaffected by atmospheric influences.

On the east of the Rocky Mountains lies the country of the "Plains," a region not unlike in its topography to the great plateau of the West, but differing in this, that it is not bordered on the east by a continuous mountain chain; that it slopes gently downward to the Mississippi, and that its eastern half has been so well watered that its valleys have been made broad and all its topographical features softened down. In former times, however, the topographical unity now conspicuous on the Plains did not exist, and the surface was marked by a series of great basins which received the flow of water from the Rocky Mountains and formed lakes, less numerous, it is true, but of greater extent than those of the far West. The northern portion of the eastern plateau has been Dr. Hayden's chosen field of exploration for many years; a field he has well tilled, and from which he has obtained a harvest of scientific truth which will form for him an enduring and enviable monument.

Among the most interesting researches of Dr. Hayden in this region are the studies he has made of the deposits which have accumulated in these great fresh-water basins. The story he has written of his explorations of this district has been so well and fully told that I shall not attempt to review it. Suffice it to say, that the series of fresh-water basins discovered by Dr. Hayden in the country bordering the Upper Missouri have proved to be as rich in new and interesting forms of animal and vegetable life as any that have been found upon the earth's surface. The vertebrate remains collected by Dr. Hayden have been carefully studied, fully described and illustrated by Dr. Leidy, and the splendid monograph which he has published of these fossils forms a contribution to paleontology not second in value or interest to that made by Cuvier in his illustrations of the fossils from the Paris basin; nor to that of Falconer and Cautley, descriptive of the fossils of the Sewalik Hills of India.

The scarcely less voluminous and interesting collections of fossil plants made by Dr. Hayden have been placed in my hands for examination. Of these, the first installments were described and drawn some years since as a contribution to the report of Colonel W. F. Raynolds, United States Army, a report not yet published by the Government. The descriptions, however, were printed in the annals of the Lyceum of Natural History of New York, vol. 9, 1868.

The general conclusions drawn from a study of this portion of Dr. Hayden's collections as regards the floras of the tertiary and cretaceous periods, the topography and climate of the interior of the continent—and which form a part of my contribution to Colonel Raynolds's report—will be found quoted on another page. Since that report was written very large additions have been made to our knowledge of our late extinct floras, by collections of fossil plants made in different portions of the western part of our continent by Dr. Hayden, Mr. Condon, Dr. Le Conte, and myself; and also by the collections made by Mr. W. H. Dall and Captain Howard in Alaska, and by several explorers on the continent of Greenland.

Deferring for the present a comparison of the plants derived from strata of similar age in these widely separated localities, and the inferences deducible from them as regards the physical geography of our continent, I should say that the flora and fauna of the lake deposits on both sides of the Rocky Mountains apparently belong to one and the same geological age, and tell the same story in regard to the topography, climate, conditions, and development of animal and vegetable life. There is this striking difference, however, perceptible at the first glance between the fresh-water tertiaries of the East and West. In Oregon, Idaho, and Nevada, volcanic materials have accumulated in the lake basins to a much greater extent than east of the Rocky Mountains; and we have abundant evidence that during the tertiary period the western margin of the continent was the scene of far greater volcanic activity than we have any record of in the Rocky Mountain belt.

The deposits formed by the lake basins of the Upper Missouri region are shales, marls, and earthy limestones, with immense quantities of lignite, but with almost no traces of volcanic products. The number of fossil plants and animals is much greater there than farther west; and we have in these deposits proof that during unnumbered ages this portion of the continent exhibited a diversified and beautiful surface, which sustained a luxuriant growth of vegetation and an amount of animal life far in excess of what it has done in modern times. This condition of things existed long enough for hundreds and even thousands of feet of sediments to accumulate in the bottoms of extensive fresh-water lakes. These lakes were gradually and slowly diminished in area by the filling up of their basins and by the wearing away of the barriers over which passed their gently flowing, draining streams. Since the deposition of the fresh-water tertiaries which occupy the places of the old lakes, great changes have taken place in the topography of this region by the upheaval of portions of the Rocky Mountain ranges. In some localities these lake deposits are found turned up on edge and resting on the flanks of the mountains which border the plains on the west. It is certain, however, that much of the Rocky Mountain belt existed anterior to this date. We have in these, and many other facts that might be cited, proofs of the truth of the assertion I have elsewhere made that these great mountain chains, though existing at least in embryo from the earliest paleozoic ages, have since then been subject to many and varied modifications; that they have been, in fact, hinges upon which the great plates of the continent have turned; lines of weakness where the changes of level experienced by the continent have been most sensibly felt.

It is a somewhat remarkable fact that the collections of fossil plants made by Dr. Hayden from different localities differ so much among themselves. In every newly, discovered plant-bed he has obtained more or less species of which we before had no knowledge, and it is even true that between some of his collections there are no connecting links. It is also true that much of the material he has collected has not yet received the study it needs. From these facts it will be seen that much yet remains to be done before the great interval of time during which this series of fresh-water tertiaries accumulated can be divided into definite periods, and before we can venture to affirm that such an epoch had a flora of such or such a botanical character, and, therefore, this or that average annual temperature. Some interesting facts came out, however, at once in the examination of these materials; to these I will briefly refer.

In the beginning of the cretaceous age, North America, as we learn, presented a broad land surface, having a climate similar to the present, and covered with forests consisting, for the most part, of trees belonging to the same genera with those that now flourish upon it. In the progress of the cretaceous age, the greater part of the continent west of the Mississippi sank beneath the ocean, and the deposits made during the later portions of the cretaceous age contain a vegetation more tropical in character than that which had preceded it. It seems probable that at this time the lands which existed as such west of the Mississippi were islands of limited extent, washed by the Gulf Stream, which apparently had then a course north and west from the Gulf of Mexico to the Arctic Sea.

The earlier tertiary epochs were, however, marked by an emergence of the continent and a gradual approach to previous and present conditions. This is indicated by the fact that the oldest tertiary deposits (eocene?) contain a flora less like the present than is that of the miocene or middle tertiary. In this category of older deposits, with a more tropical flora, I would place the Green River tertiary beds, those of Mississippi, studied by Lesquereux, and those of Brandon, Vermont.

In the miocene age the continental surface was broader, the lake basins of the West contained only fresh water, and the land surface was covered with vegetation very much like that of the present day, a number of miocene species still existing. The climate of the continent in the miocene age was much milder than now. Fan-palms then grew as far north as the Yellowstone River, and a flora flourished in Alaska and on Greenland as varied and as luxuriant as now grows along the fortieth parallel. At this time there must have been some sort of land connection between our continent and Europe on the one hand and Asia on the other. The flora of all these regions was essentially the same, and a large number of plants were common to the three continents. In this age the mammalian fauna of our continent exhibited the same remarkable development that it did in Europe and Asia; and over our western plains roved herds of great quadrupeds, rivaling in number and variety those that have struck with wonder and surprise every traveler in South Africa.

This state of things seems to have continued through the pliocene age and up to the time when the climate of the continent was completely revolutionized by the advent of the "ice period." The change which took place at that time was such as taxes the imagination to conceive of as much as it taxes the reasoning powers to account for.

We have seen that in the middle tertiary age the climate of Alaska and Greenland was that of New York and St. Louis at present. In the next succeeding period, the glacial epoch, the present climate of Greenland was brought down to New York, and all the northern portion of the continent wrapped in ice and snow. This change was undoubtedly gradual, (for nature does not often "turn a corner,") but it is plain that it must have resulted in the gradual driving southward of all the varied forms of animal and vegetable life that were spread over the continent to the Arctic Sea. When glaciers reached as far south as the fortieth parallel it is evident that a cold, temperate climate prevailed in Mexico, and that only in the south of Mexico would the average annual temperature have been what it was previously in the latitude of New York. We must conclude, therefore, that the herds of mammals which once covered the plains of the interior of North America were forced by the advancing cold into such narrow limits in Southern Mexico that nearly all were exterminated. Plants bore their expatriation better; inasmuch as a tree, even of the most gigantic size, will live upon the space occupied by its roots, provided the climatic conditions are favorable; while one of the larger mammals would require at least a thousand times this space for its support. As a consequence, we find the present flora of our continent much more like that of the miocene than is our fauna, though the change to which I have referred seems to have been fatal to quite a number of the most abundant and interesting of our miocene forest trees. Of these, the *Glyptostrobus* may be taken as an example. This was a beautiful conifer which, in miocene times, grew all over our continent and over Northern Europe. In the change to the glacial period, however, it was exterminated, both there and here, yet continued to exist in China—where a miocene colony from America had taken root—and it is growing there at the present time. This great ice-wedge which came down from the north separated very widely many elements in our miocene flora which have never since been reunited, so that when the storm had passed and better days had come, and the Mississippi Valley and Atlantic States were repossessed by the descendants of the tertiary plants, they were still separated, by many thousand miles, from their brethren which had formerly crossed the now submerged bridge of Behring's Straits; and thus the two kindreds have been growing, and flowering, and seeding, and dying in each colony far beyond the reach of the other and developing their peculiarities each in its own way from generation to generation. When now we come to compare the present flora of China and Japan with that of the eastern half of our continent, we find the strongest proofs of their intimate relationship. Many of the species are identical, while others are but slightly changed, and, on the whole, the differences are less than such as have grown out of separation in human kindred colonies in an infinitely shorter period.

Among the great mammals that formerly inhabited our continent, but such as are now extinct, there were some which seem to have bid defiance to the changes I have detailed. These were particularly the mastodon and elephant, both of which were probably capable of enduring great severity of climate. The mammoth, we know, was well defended from the cold by a thick coat of hair and wool, and was probably capable of enduring a degree of cold as severe as that in which the musk-ox now lives. We know that both these great monsters—the elephant and mastodon—continued to inhabit the interior of our continent long after the glaciers had retreated beyond the upper lakes, and when the minutest details of surface topography were the same as now. This is proven by the fact that we not unfrequently find them embedded in peat in marshes which are still marshes, where they have been mired and suffocated. It is even claimed that here, as on the European continent, man was a cotemporary of the mammoth, and that here, as there, he contributed largely to its final extinction. On this point, however, more and better evidence than any yet obtained is necessary, before we can consider the cotemporaneity of man and the elephant in America as proven. The wanting proof may be obtained to-morrow, but to-day we are without it.

The pictures which geology holds up to our view of North America during the tertiary ages are in all respects, but one, more attractive and interesting than could be drawn from its present aspects. Then a warm and genial climate prevailed from the Gulf to the Arctic Sea; the Canadian highlands were higher, but the Rocky Mountains lower and less broad. Most of the continent exhibited an undulating surface, rounded hills and broad valleys covered with forests grander than any of the present day, or wide expanses of rich savannah, over which roamed countless herds of animals, many of gigantic size, of which our present meager fauna retains but a few dwarfed representatives. Noble rivers flowed through plains and valleys, and sea-like lakes, broader and more numerous than those the continent now bears, diversified the scenery. Through unnumbered ages the seasons ran their ceaseless course, the sun rose and set, moons waxed and waned over this fair land, but no human eye was there to mark its beauty, nor human intellect to control and use its exuberant fertility. Flowers opened their many-colored petals on meadow and hill-side, and filled the air with their perfumes, but only for the delectation of the wandering bee. Fruits ripened in the sun, but there was no *hand* there to pluck, nor any speaking tongue to taste. Birds sang in the trees, but for no ears but their own. The surface of lake or river was whitened by no sail, nor furrowed by any prow but the breast of the water-fowl; and the far-reaching shores echoed no sound but the dash of the waves and the lowing of the herds that slaked their thirst in the crystal waters.

Life and beauty were everywhere, and man, the great destroyer, had not yet come; but not all was peace and harmony in this Arcadia. The forces of nature are always at war, and redundant life compels abundant death. The innumerable species of animals and plants had each its hereditary enemy, and the struggle of life was so sharp and bitter that in the lapse of ages many genera and species were blotted out forever.

The herds of herbivores—which included all the genera now living on the earth's surface, with many strange forms long since extinct—formed the prey of carnivores commensurate to these in power and numbers. The coo of the dove and the whistle of the quail were answered by the scream of the eagle, and the lowing of herds and the bleating of flocks come to the ear of the imagination mingled with the roar of the lion, the howl of the wolf, and the despairing cry of the victim. Yielding to the slow-acting but irresistible forces of nature, each in succession of these various animal forms has disappeared till all have passed away or been changed to their modern representatives, while the country they inhabited, by the upheaval of its mountains, the deepening of its valleys, the filling and draining of its great lakes has become what it is.

These changes which I have reviewed in an hour seem like the swiftly-consecutive pictures of the phantasmagoria or the shifting scenes of the drama, but the æons of time in which they were effected are simply infinite and incomprehensible to us. We have no reason to suppose that *terra firma* was less firm, or that the order of nature in which no change is recorded within the historic period, was less constant then than now. At the present rate of change—throwing out man's influence—a period infinite to us would be required to revolutionize the climate, flora, and fauna, but there is no evidence that changes were more rapid during the tertiary ages.

Every day sees something taken from the rocky barrier of Niagara; and, geologically speaking, at no remote time our great lakes will have shared the fate of those that once existed at the far West. Already they have been reduced to less than half their former area, and the water level has been depressed three hundred feet or more. This process is pretty sure to go until they are completely emptied.

The cities that now stand upon their banks will, ere that time, have grown colossal in size, then gray with age, then have fallen into decadence and their sites be long forgotten, but in the sediments that are now accumulating in these lake basins will lie many a wreck and skeleton, tree trunk and floated leaf. Near the city sites and old river mouths these sediments will be full of relics that will illustrate and explain the mingled comedy and tragedy of human life. These relics the geologist of the future will doubtless gather and study and moralize over, as we do the records of the tertiary ages. Doubtless he will be taught the same lesson we are, that human life is infinitely short, and human achievement utterly insignificant. Let us hope that this future man, purer in morals and clearer in intellect than we, may find as much to admire in the records of this first epoch of the reign of man as we do in those of the reign of mammals.

IV.—REPORT ON THE VERTEBRATE FOSSILS OF THE TERTIARY FORMATIONS OF THE WEST.

BY PROF. JOSEPH LEIDY.

In the present report the writer has simply given a brief notice of the various vertebrated animals whose fossil remains have been collected in the tertiary deposits of the West. For a full account of most of the extinct mammals which are subjects of notice, the reader is referred to the work entitled "The Extinct Mammalian Fauna of Dakota and Nebraska," published in the seventh volume of the Journal of the Academy of Natural Sciences of Philadelphia. More or less full accounts of the other animals, also the subjects of notice, are published in Owen's Geological Survey, the fifth volume of the Pacific Railroad Reports, the contributions of the Smithsonian Institution, and the Proceedings of the Academy of Natural Sciences of Philadelphia.

The vertebrate fossils collected in Professor Hayden's last two expeditions, though forming part of the material of the report, will be more fully described and illustrated in an extended treatise in future.

The short time allowed for the preparation of the report amid the many duties of the writer, must serve as his apology for its imperfect character.

The tertiary formations of the North American continent west of the Mississippi, so far as they have been explored, in the States and Territories of Kansas, Dakota, Nebraska, Wyoming, Colorado, Idaho, California, and Oregon, have yielded a great quantity of remains of vertebrated animals, indicating different races which existed in earlier ages, and which have entirely passed away. The principal deposits from which the greater number of fossil remains have been obtained are those of the *mauvaises terres* of White River, Dakota, those of the valley of the Niobrara River, Nebraska, and the Bridger Group of rocks, near Fort Bridger, Wyoming. The deposits especially referred to appear to be all of fresh-water origin, and to have belonged to the middle and later tertiary epochs.

Most of the vertebrated remains submitted to the examination of the author are part of the valuable fruits of the geological explorations of Professor Hayden, either engaged in expeditions of others, or under his own control. Many have been obtained in the explorations of Dr. David Dale Owen, Dr. John Evans, Mr. F. B. Meek, Mr. Clarence King, and others.

By far the greater number of vertebrated remains are those of mammals, though some of the same or cotemporaneous formations are rich in the evidences of reptilian life, and likewise those of fishes.

MAMMALIA.

The mammalian remains of the western tertiary formations appear mainly to belong to the miocene period, though many evidently pertain to a later age than the others, and most likely belong to the pliocene period. Perhaps also a few of the remains belong at least to the later part of the eocene period, especially those found in the lowest strata of the *mauvaises terres* of White River, Dakota, and those found in the Bridger Group of tertiary rocks of Wyoming.

The fossil remains of mammals thus far collected in the western tertiary formations indicate upwards of one hundred species, mostly of extinct genera, and many of those peculiar to the North American continent. Notwithstanding the large number mentioned, it is but a meager representation of the extensive faunæ to which they belonged. Probably, also, it is but a small proportion of the number which will be discovered in future explorations. The fossils represent nearly all the orders, especially those of *Carnivora*, *Ruminantia*, *Artiodactyla*, *Perrisodactyla*, and *Solidungula*. The *Rodentia* and *Insectivora* are also fairly represented. No remains of *Quadrumana*, *Cheiroptera*, and, singularly enough, of *Marsupialia*, have been discovered.

CARNIVORA.

The carnivorous order of mammals is well represented by remains in the tertiary deposits of our Western Territories. The number and variety of the fossils indicate a development proportionate to the teeming population of cotemporaneous herbivora which supplied the flesh-eaters with food.

CANIDÆ.

The canine family during the pliocene was represented, as in later times, by several species of wolves; during the miocene period it was represented by an allied and subsequently extinct genus, the *Amphicyon*, which also existed cotemporaneously in Europe.

CANIS,

The genus to which our wolves, dogs, and foxes belong.

Canis sævus.—An extinct species of wolf, probably a near relative, if not the progenitor of the existing American wolf, (*Canis occidentalis*,) is indicated by portions of two lower jaws obtained by Professor Hayden from the sands of the Niobrara River, Nebraska.

Canis temerarius.—A second species of wolf, intermediate in size with the prairie wolf (*Canis latrans*,) and the red fox (*Canis fulvus;*) is indicated by fragments of jaws found in company with the preceding specimens.

Canis vafer.—A species of fox, about the size of the living swift fox (*Canis velox*,) is indicated by portions of jaws obtained by Professor Hayden, in association with the preceding specimens.

Canis Haydeni.—An extinct species, of more robust proportions than any of the living American wolves; indicated by the greater portion of one side of a lower jaw; also found by Professor Hayden in the same locality as the former specimens.

The remains of four species of wolves found in association, in the Niobrara sands, indicate that these ravenous animals were abundant during the later tertiary period. Their number appears to have held a relationship with the cotemporaneous abundance of herbivorous animals.

AMPHICYON.

An extinct genus of carnivorous animals, to which the above name has been given, was established on fossil remains discovered in the middle tertiary deposits of France and Germany. The general form and construction of the skull and the character of the teeth indicate a near relationship in the animals of this genus to the wolves. A dozen species have been indicated as having formerly lived in Europe; one of them having been viewed by Cuvier as a "dog of gigantic proportions."

The remains of two species referable to the same genus have been discovered in the miocene tertiary deposits of the *Mauvaises Terres* of White River, Dakota. They are as follows:

Amphicyon vetus.—A species about the size of the living prairie wolf (*Canis latrans*,) indicated by the mutilated cranium and fragments of jaws, with teeth; discovered by Dr. John Evans and Professsor Hayden.

Amphicyon gracilis.—A small species, less in size than any of the existing American foxes. It is indicated by fragments of jaws, with teeth, and the facial portion of a skull of several individuals; all discovered by Professor Hayden.

HYÆNODONTIDÆ

Is the name given to an extinct and remarkable family of animals, exhibiting a relationship to the canine family on one hand, and the feline family on the other, together with ties to others.

HYÆNODON.

One of the most remarkable extinct genera of carnivorous animals is that to which the above name has been given. It belongs to no existing family, and, indeed, is so peculiar as to have become the type of an independent family. In anatomical character it partakes of those of the wolf, the tiger, the hyena, and the weasel, the raccoon, and the opossum. Originally discovered in France, the remains of five or six species have been obtained from the lower miocene and upper eocene formations of that country. Three American species are indicated by fossil remains obtained in the lower miocene tertiary beds of the Mauvaises Terres of White River, by Dr. John Evans, Dr. Benjamin Shumard, Professor Hayden, and Mr. Meek. These species are as follows:

Hyænodon horridus.—The largest known species, and one of the most sanguinary of terrestrial mammals that has ever existed. Cotemporaneous with a multitude of herbivorous animals, many of which were gregarious in extensive herds, it was no doubt a fearful scourge to them. It is indicated by the greater portions of three skulls, together with fragments of jaws and teeth of other individuals. The size of the animal was about equal to that of the largest black bears. The specimens of jaws and teeth discovered have afforded us a view of the entire dentition of the animal, which is truly formidable. Besides the powerful canine teeth, the series of molars affords the unusual exhibition of three teeth, constructed nearly after the model of the single sectorial tooth of other carnivorous mammals, though the last one alone reaches the full development of the corresponding tooth in the latter.

The true sectorial molars of hyænodon, the last of the series of teeth, are constructed like those of the lion and tiger. These teeth, the broadest and strongest of all, combine the mechanism of the wedge and the scissors, and are admirably adapted to cutting animal tissues, including bones.

The large temporal fossæ occupying the sides of the skull, and separated only by a long and high median ridge, sufficiently prove the great power of the muscles which operated on the long levers of the lower jaw. Certainly no other animal which lived cotemporaneously with this formidable creature could have resisted its power. The skull of the species measures about a foot in length.

Hyænodon crucians.—This is the name given to a species not much exceeding in size the red fox *(Canis fulvus.)* A half dozen imperfect skulls of the animal, together with fragments of jaws and teeth, and other bones, have been discovered. Though small, compared with the preceding species, this one was no doubt equally destructive to the smaller herbivorous animals.

Hyænodon cruentus.—A species thus named, intermediate in size to the two foregoing, is indicated by several fragments of jaws and teeth found in association with the remains of the former.

FELIDÆ.

The feline animals forming the family with the above name were well represented among the carnivores of both the middle and later tertiary periods of Dakota and Nebraska.

PSEUDÆLURUS.

This genus, differing from that of felis or the true cats only in the possession of an additional small tooth to the molar series of the lower jaw, was originally named from remains found in the middle tertiary formation of France.

Pseudælurus intrepidus.—This species is indicated by a well-preserved lower jaw, discovered by Professor Hayden in the pliocene sands of the Niobrara Valley of Nebraska. It was intermediate in size to the panther *(Felis concolor)* and the lynx, *(Felis canadensis,)* and in anatomical character and habits was no doubt very similar.

DREPANODON.

This remarkable feline genus, fortunately for animals of a more peaceful nature, now utterly extinct, during the tertiary period appears to have had a wide range of distribution throughout the earth. Its remains have been discovered in the middle and later tertiary formations of Western Europe, Greece, the sub-Himalayan Mountains of Asia, and of both Americas. Several of the larger species equaled in size the lion and tiger, and, judging from their formidable array of destructive weapons, were of even greater ferocity. In comparison with the existing feline animals they are especially marked by the greater proportionate size and compressed form of the upper canine teeth, which have given to the animals the name of saber-toothed tigers.

Two species of the genus appear to have inhabited Dakota during the formation of the *mauvaises terres* deposits of White River.

Drepanodon primævus.—A species not quite so large as the living panther is indicated by a number of skulls, jaw fragments with teeth, and other bones, first collected by the late Drs. Evans and Shumard, and subsequently by Professor Hayden and Mr. Meek. Two of the skulls that have been found exhibit the marks of conflict with some equally rapacious animal, most probably the largest *Hyænodon*, as the depressions made by the teeth on opposite sides of the specimens exactly correspond with the prints of the canines of the latter.

Drepanodon occidentalis.—The second species, indicated by several jaw fragments, discovered by Dr. Hayden, was about the size of the existing panther.

DINICTIS.

This name has been appropriated to an extinct genus of feline animals, represented by remains, thus far only discovered in the *mauvaises terres* miocene deposits of White River, Dakota. It is nearly allied to the preceding genus, but differs from it in the possession of two additional teeth to the molar series of the lower jaw.

Dinictis felina.—A unique species, indicated by two nearly complete skulls, both discovered by Professor Hayden. The animal was rather less in size than the existing panther, and about equaled the smaller species of *Drepanodon*, with which it was cotemporaneous. It possessed the same formidable character of upper canines as in the latter genus. From the number and disposition of the teeth, according with those of the weasel, it has been called the saber-toothed weasel. The skull measures six and a quarter inches in length.

ÆLURODON.

An extinct genus, probably feline, perhaps canine, distinguished by the above name, is founded on an isolated tooth discovered by Professor Hayden in the pliocene sands of the Niobrara Valley. The tooth is an upper sectorial molar, and is intermediate in character to that of the wolves and cats.

Ælurodon ferox.—The species was nearly as large as the Bengal tiger.

PATRIOFELIS.

This name has been appropriated to another extinct and supposed feline genus, founded on fragments of a fossil jaw obtained by Professor Hayden from the tertiary formation near Fort Bridger, Wyoming.

Patriofelis ulta.—The species was rather larger than our panther. The length of its lower jaw is about six inches.

LEPTARCTUS.

An extinct genus, to which the above name has been given, is inferred to have existed during the tertiary period, from a single tooth discovered by Professor Hayden, in association with remains of extinct equine genera, at Bijou Hill, east of the Missouri River, about ten miles below the mouth of White River, Dakota. The tooth apparently indicates a carnivorous animal allied to the living coati of South America.

Leptarctus primus.—The species was about the size of the raccoon.

NOTHARCTUS.

An extinct genus, with the above name, is founded on a portion of the lower jaw, obtained during the last expedition of Professor Hayden. It was discovered on Black's Fork, and pertains to the Bridger tertiary deposit.

Notharctus tenebrosus.—The species distinguished by this name was about two-thirds the size of the raccoon, to which it was also related.

RUMINANTIA.

The ruminating order of mammals is represented by an abundance of remains in the western tertiary deposits. Most of the members not only belong to extinct genera, but to such as are peculiar to the North American continent.

BOVIDÆ.

Bison.

Our western buffalo, or bison, was probably represented during the post-pliocene or quaternary period by a much larger animal, the remains of which have been found, in association with those of the

American mastodon, both in the eastern and western portions of the continent.

Bison latifrons.—The great extinct bison of America was originally indicated by a portion of a skull discovered on a tributary of the Ohio River about a dozen miles from the famous deposit of bones, Big-Bone Lick, Kentucky. Remains have also been found in the latter locality, on the Brazos River, Texas, and elsewhere. The cranial portion of a skull, apparently of the same species, was discovered in California, by Walter Brown, of San Francisco, and was presented to the Academy of Natural Sciences of Philadelphia. The species was about as large as the living buffalo or arnee of India and Java.

OREODONTIDÆ.

The above name is given to an extinct family of animals, the remains of which, discovered in the Western Territories of the United States, indicate that during the tertiary period it embraced many genera and species. The members of the family in anatomical character exhibit strong suilline affinities, while the structure of their grinding teeth indicate them to have chewed the cud like our ruminating animals. Their feet were constructed nearly as in the hog, and, as in this animal, were provided with four toes.

The skull of the oreodonts approaches in form that of the peccaries. The cranial portion resembles that of the camel, and, as in this, is hornless. The temporal fossæ are large and separated by a median sagittal crest, as in the camel. The orbits are closed behind by an arch, as in the latter, and other living ruminants. Large and comparatively deep depressions occupy a position just in advance of the orbits, as in the living deer family, but no unossified spaces occupy any part of the face. The teeth in both jaws form nearly unbroken arches, a condition in which we find none of the allied living families, and but few of any other living mammalia. Well-developed incisors occupy both jaws, such as exist alone in the lower jaw of living ruminating animals. The canine teeth approach in character most nearly those of suilline animals. The grinders are constructed like those of the living ruminants, resembling most nearly those of the deer family.

OREODON.

The remains of this genus are of all other fossils the most abundant of those which have been discovered in the miocene tertiary deposits of the *mauvaises terres* of White River, Dakota. Two species especially, judging from the great quantity of their remains which have been collected, appear to have formerly existed in immense numbers. They were most likely gregarious, in the manner of the existing peccaries, and, like the modern bison, roamed together in great herds over the extensive prairies of the West. Compared with the latter animal they were insignificant in size, and in this respect approached the former.

Oreodon Culbertsoni.—This species, the remains of which have been discovered in the greatest abundance, was first brought to our notice by Messrs Alexander and Thaddeus Culbertson. These gentlemen, brothers, engaged in the fur trade, were the first to collect fossils from the *mauvaises terres*, and place them in the hands of naturalists. *Oreodon Culbertsoni*, named in their honor, was intermediate in size and appearance to the domestic sheep and the collared peccary. Skulls, fragments of jaws with teeth, and other bones of the skeleton of upwards of a thousand individuals of this species have come under the inspection of the writer. In the large number of specimens representing so many individuals, considerable variation in the details of structure have been noticed. The fossils also exhibit great variety in the condition of preservation. Among them are some crushed in such a way as to indicate that the condition was due to the bite of certain of the powerful carnivores which were contemporaneous with the animals.

Oreodon gracilis.—A small species, about the size of a musk deer; was an associate of the former. It was probably equally abundant, but the greater delicacy of its skeleton rendered it more liable to a variety of accidents insuring destruction.

Oreodon major.—A larger species than either of the former, indicated by a few remains, among them a nearly entire and well-preserved skull, discovered by Professor Hayden in the *mauvaises terres* deposits of White River. The skull measures about ten inches in length; and the animal was about as large as the ordinary wolf or the largest-sized dog. The species is remarkable for the large size of its ear capsules, which not only greatly exceeded in proportion those of the *Oreodon Culbertsoni* and *O. gracilis*, but are larger than in the existing hog. What relationship the inflated or enlarged condition of the ear capsules has with the acuteness of hearing or the habits of animals has not been clearly indicated. The comparative scarcity of the remains of *Oreodon major* in the localities in which those of the preceding species were obtained leads me to suspect that the former was probably not cotemporaneous with the latter, or at least did not inhabit the same places.

A few remains from the *mauvaises terres* of White River, which the writer had referred to two species of oreodon, distinct from the preceding under the names of *Oreodon affinis* and *O. hybridus*, I suspect to have pertained to hybrids; probably of *O. gracilis* and *O. major*.

In 1866, Professor Hayden obtained among a number of remains of *Oreodon Culbertsoni*, from the *mauvaises terres*, a specimen of a skull, agreeing in size, form, and details with that of the species just named, except that it had the ear capsules proportionately as well developed as in *O. major*. I referred it to a distinct species with the name of *Oreodon bullatus*, but I suspect it pertained to a hybrid between *O. major* and *O. Culbertsoni*. It is not unlikely that *Oreodon major* may have lived in a locality skirting that inhabited by the species *O. Culbertsoni* and *O. gracilis*. The intimate relationship anatomically and physiologically would readily allow of the hybridization which has been suspected.

Oreodon superbus.—Last autumn the writer received through the Smithsonian Institution, for examination, a collection of mammalian fossils from the Reverend Thomas Condon, of Dalles City, Oregon. They were mainly collected in the valley of Bridge Creek, a tributary of John Day's River, Oregon. The fossils in general appearance and condition of petrifaction resemble those of the *mauvaises terres* of White River, Dakota.

The greater number and more striking specimens belong apparently to a species of oreodon larger than any of those from the locality last named. The skull of the animal was about fourteen inches in length. The ear capsules are inflated and proportionately as large as in *O. major*. The face is rather more abruptly narrowed in advance of the orbits than in the latter; the infra-orbital arches are proportionately deeper, and the lachrymal depressions are shallower. The teeth have the same constitution as in the *mauvaises terres* oreodons, but the canines and premolars are proportionately wider and thinner, and thus appear of a more compressed character. The inferior canine tooth, at the base of the crown is an inch in breadth fore and aft. The species I have distinguished by the name heading this article.

Mingled with the remains of *O. superbus* are a few fragments, apparently referable to *O. Culbertsoni.*

MERYCOCHŒRUS.

As the name of the genus indicates, a ruminating hog, like oreodon, and pertaining to the same family. It is closely related to the latter genus, and perhaps by many naturalists would be regarded as the same. Its chief differences consist in the proportionately great depth of the infra-orbital arch, the abruptly-narrowed face, the comparatively-shallow lachrymal depression, and the more posterior position of the infra-orbital foramen. The characters thus presented were more sharply defined previous to the recent discovery of a second species of the genus, which is intermediate, and therefore still more nearly approximates the two genera, if it does not merge the one into the other.

Merycochœrus proprius.—The remains of this species were discovered by Professor Hayden, during Warren's expedition of 1857, on the head-waters of the Niobrara River, opposite Fort Laramie. They were embedded in a dull, reddish-brown sandstone, which Professor Hayden refers to the miocene tertiary period. The animal was larger than any of the species of oreodon, except the *O. superbus* of Oregon, which it approximated in size. The jaws are of more robust proportions than in the oreodons, and the infra-orbital arches of greater depth. In this the latter measure nearly two inches; in *O. superbus*, an animal of about the same size, an inch and a half; in *O. major*, three-fourths of an inch.

Merycochœrus proprius appears not to have inhabited the same localities with the oreodons, at least cotemporaneously. I suspect it to have lived at a later period, and perhaps, on the theory of the distinguished philosopher Darwin, may have been the successor by selection of the oreodons.

Merycochœrus rusticus.—A second species of the genus distinguished by his name is indicated by remains recently discovered by Professor Hayden, on the Sweetwater River, eighteen miles west of Devil's Gate, Wyoming Territory. The animal was about the size of *Oreodon major*, but is readily distinguishable through the anatomical characters that separate the two genera to which they belong. The number of remains of *M. rusticus* obtained during a short period from a circumscribed locality indicate the animal to have been abundant.

MERYCHYUS.

Another genus of the oreodont family to which the above name has been given is indicated by a comparative abundance of remains discovered by Professor Hayden during Warren's expedition in 1857. The fossils were found in the loose sands of the Niobrara River, and are regarded by Professor Hayden as being of more recent date than those of the oreodons, the age of the formation being considered as later tertiary or pliocene.

Merychyus is clearly related to oreodon and *Merycochœrus*, and, like the latter, most probably is the successor of oreodon. The construction and form of the skull and teeth are nearly alike in all the genera mentioned.

The true molars or grinding teeth of *Merychyus* are constructed on the same plan as in all ordinary ruminants, recent and extinct, and are intermediate in character with those which have short crowns, as in the other oreodonts and the deer, and those which have long crowns, as in the camel and sheep.

The species of *Merychyus*, during the later tertiary period, appear to have taken the place of the oreodons of the middle tertiary period. The remains discovered appear to indicate three species of the genus.

Merychyus elegans.—A small species, distinguished by this name, was intermediate in size to *Oreodon Culbertsoni* and *O. gracilis*, or was about the size of the existing collared peccary.

Merychyus medius.—This species, indicated by a few fragments, was rather larger than the existing lama of South America.

Merychyus major.—Fragments of jaws and teeth indicate this species to have been about the size of *Merycochœrus proprius*, and nearly as large as the existing camel.

LEPTAUCHENIA.

Another extinct genus of ruminants of the same family as the preceding, distinguished by the above name, was first indicated by a few remains discovered by Professor Hayden in 1855, on one of the tributaries of White River, near Eagle Nest Butte, Dakota. Subsequently, Professor Hayden, during his exploration of 1866, discovered additional and more complete remains of the same genus on White Earth Creek, a tributary of White River, Dakota. The fossils are attributed by Professor Hayden to the miocene formation.

The skull of *Leptauchenia* has the general form and construction as in the preceding genera of oreodonts, and the number, form, and constitution of the teeth are nearly the same.

The ear capsules are proportionately larger than in any of the other members of the family. Large unossified spaces exist at the sides of the face, extending from the forehead and in advance of the lachrymal bones. Similar spaces exist in the living deer and lama, but not in the other oreodonts so far as known.

The true molar teeth or grinders of *Leptauchenia* most nearly resemble those of *Merychyus*, but exhibit differences. The median buttress-like ridges on the outer part of the upper grinders divide the crown to the fangs more completely than in *Merychyus;* and in the lower grinders the crown internally is divided by corresponding ridges, which are nearly or quite obsolete in *Merychyus.*

The fossil remains thus far discovered indicate the existence of three species of *Leptauchenia* during the miocene period. Cotemporaneous with the species of *Oreodon* and *Merycochœrus* they appear to have been the predecessors of the species of *Merychyus* of the pliocene period. They were all comparatively small, and have been distinguished by the following names:

Leptauchenia major.—The largest species of the genus was intermediate in size with *Oreodon Culbertsoni* and *O. gracilis.* The length of its skull was about five and three-quarter inches.

Leptauchenia decora.—Rather smaller than *O. gracilis*, had the skull about four inches long.

Leptauchenia nitida.—The smallest of the species was about the size of the living musk deer. Its skull is three and a half inches in length.

AGRIOCHŒRIDÆ.

Another genus of extinct, hog-like ruminants, allied to the genera of the preceding family, is nevertheless so peculiar that the author has viewed it as the representative of a distinct family to which he has given the above name. Its principal features distinguishing it from the oreodonts are as follows:

The orbits are open behind, or not separated from the temporal fossæ, in which character they differ from those of all known ruminants, recent or extinct, having the same form of grinding teeth. No lachrymal fossæ exist in front of the orbits as in the oreodonts.

The number, relation, and general constitution of the teeth are the same as in the latter; but the grinders or true molars, though constructed on the same plan as in the oreodonts and the ruminants generally, are remarkable for their transversely spreading character, or the comparative shallowness and breadth of their crowns. The last premolar departs from the usual ruminant pattern, the upper having three lobes to the crown, the lower four lobes.

AGRIOCHŒRUS.

Three species of this genus have apparently been recognized, differing little in size, and in this respect approaching *O. Culbertsoni.* The form and general construction of the skull are nearly the same as in the latter. Besides the orbits being open behind, and the absence of lachrymal fossæ, as above mentioned, the face, in comparison with that of oreodon, is proportionately wider and of less depth. The remains of *Agriochœrus* have been discovered in the *mauvaises terres* of Dakota, but are comparatively rare.

Agriochoerus antiquus.—The remains of this species, consisting of fragments of jaws and teeth, together with the facial portion of a skull, of two individuals, were among the first of the mammalian fossils collected in the *mauvaises terres* of Dakota. They were obtained from a fur trader by the late Dr. Hiram A. Prout, of St. Louis, by whom they were submitted to the examination of the writer. Among several tons of fossil bones subsequently collected in the *mauvaises terres* and brought to our notice, only the smallest traces of this species were detected.

The size of the skull was about equal to that of *O. Culbertsoni.*

Agriochœrus latifrons.—This species is indicated by an almost complete skull, obtained by Professor Hayden, in the *mauvaises terres* of Dakota, during his expedition of the summer of 1866. It differed little in size from the preceding species, but is distinguishable by the breadth of its forehead, which is almost one-third greater. Large inflated ear capsules are present in the skull of *A. latifrons*, proportionately as well developed as in *O. major.*

The skull of *A. latifrons* is eight and a half inches long.

Agriochœrus major.—A somewhat larger species than the two preceding, apparently indicated by a few fragments.

CAMELIDÆ.

The camel family at the present time is represented among the indigenous animals of the western hemisphere by the various species of the lama genus of South America. During the tertiary period many members of the same family were largely distributed in the western part of North America. Recently some remains discovered in California, and submitted to the examination of the writer by Professor J. D. Whitney, indicate a species of lama exceeding in size the existing camel. The species has been named *Auchenia* or *Lama californica.*

CAMELOPS

Is the name of an extinct genus allied to the lama, indicated by a jaw fragment found in the post pliocene gravel drifts of Kansas. The species is named *C. kansanus.*

PROCAMELUS.

An extinct genus established on remains discovered by Professor Hayden in the pliocene sands of the Niobrara River, Nebraska. Fragments of jaws and teeth exhibit a near relationship in the anatomical characters of the skull to that of the existing members of the camel family. It possessed a greater number of molar teeth than the camels and lamas. Three species of the genus are apparently indicated by the fossil remains.

Procamelus robustus.—The largest species, founded on a portion of a lower jaw, pertaining to an animal about the size of the living camel. Its teeth were smaller than in the latter, but this difference was fully compensated in the greater number of these organs.

Some additional remains of the same species were subsequently discovered by Professor Hayden, on Little White River, Dakota.

Procamelus occidentalis.—A species indicated by a greater number of fossil specimens than the preceding, was about two-thirds the size of the former. Some remains, apparently of the same animal, subsequently discovered on the Little White River, Dakota, lead to the probability that all referred to the species thus named may belong to the female of the former one.

Procamelus gracilis.—A small species, not larger than the domestic sheep, indicated by several fragments of jaws and teeth.

HOMOCAMELUS.

An extinct genus, closely allied to the former, to which the above name is given, is indicated by several fragments of jaws with teeth, obtained by Professor Hayden in the pliocene sands of the Niobrara River.

Homocamelus caninus.—The species, named from the conspicuous character of the anterior teeth of the upper jaw, was about the size of the living lama.

MERYCODUS.

This extinct genus of ruminants was originally founded on a jaw fragment discovered by Messrs. Meek and Hayden, in 1853, on Bijou Hill, east of the Missouri River. Subsequently Professor Hayden discovered additional and more characteristic remains of the same, mainly consisting of fragments of lower jaws with teeth, on the Niobrara River, and on Little White River.

Merycodus necatus.—The species was smaller than the domestic sheep.

PŒBROTHERIUM,

Another extinct genus of the camel family, was founded on the greater portion of a skull, which was one of the first fossil specimens produced from the great tertiary cemeteries of the West. The specimen was discovered by Mr. Alexander Culbertson, in the *mauvaises terres* of White River, Dakota, and was presented in 1846 to the Academy of Natural Sciences of Philadelphia. The remains of the genus appear to be exceedingly rare, as a very few trifling fragments have been since discovered.

Pœbrotherium Wilsoni.—The species, approximating in size the domestic sheep, is named in honor of Dr. T. B. Wilson, late of Philadelphia, and a distinguished patron of natural history.

PROTOMERYX.

Another extinct member of the camel family, distinguished by the above name, is founded on a jaw fragment obtained by Professor Hayden from the miocene deposit of Bear Creek, a tributary of White River, Dakota. It apparently possessed the same number and arrangement of teeth as the former two genera.

Protomeryx Halli.—The species, about the size of the domestic sheep, is named in honor of James Hall, the eminent geologist and paleontologist.

MEGALOMERYX.

This generic name has been appropriated to a large ruminant apparently of the camel family. It is founded on a couple of specimens of large, inferior molar teeth obtained by Professor Hayden from the pliocene sands of the Niobrara River. The genus is probably the same as that to which our living lama and alpaca belong.

Megalomeryx niobrarensis.—The species exceeded in size the existing camel.

MOSCHIDÆ.

The family to which pertain the musks, or musk-deers at the present period, is chiefly confined to the continent of Asia and the adjacent islands. It was represented during the miocene tertiary period in North America, by an extinct genus to which the following name has been given:

LEPTOMERYX.

The genus was first characterized by a mutilated skull, discovered by Dr. John Evans, in the *Mauvaises Terres* of White River, Dakota. Subsequently Professor Hayden obtained portions of several less well-preserved skulls, together with many fragments of jaws and teeth, partly from the same locality and partly from Bear Creek, a tributary of the Cheyenne River.

Leptomeryx Evansi.—The skull indicates an animal about the size of the musk deer of Thibet. The species is named in honor of its discoverer, the late Dr. John Evans.

CERVIDÆ.

The deer family, so far as known, is poorly represented in the tertiary and quaternary deposits of the North American continent. However, a larger species of deer than any now living is indicated by remains found in association with those of the American mastodon.

CERVUS.

The genus was probably in existence in the pliocene fauna of Nebraska. A few remains, attributed to an extinct species, have been found in the sands of the Niobrara River.

Cervus Warreni.—The species was about the size of the living Virginia deer. It is named in honor of General G. K. Warren, during whose expedition its remains were discovered by Professor Hayden.

ANTILOPIDÆ.

The antelope family appears to have been represented in the pliocene fauna of Nebraska, by a peculiar genus, having furcated horn cores.

COSORYX.

The peculiar genus thus named and just alluded to is founded on several fragments of horn cores—they may be of antlers—discovered by Professor Hayden in the sands of the Niobrara River. A species, apparently of the same genus, has been described under the name of *Antilope dichotoma*, from the tertiary formations of Gers, in France.

Cosoryx furcatus.—The Niobrara species thus named was about the size of the sheep.

CAMELOPERDALIDÆ.

A singular fossil, obtained by Professor Hayden from Dr. Gehrung, of Colorado City, submitted to the writer for examination, leads to the suppositon that it belonged to a large ruminant, probably of the same family as the existing camelopard of Africa. It has been referred to an unknown genus, with the following name:

MEGACEROPS.

The genus is based on a skull fragment, of remarkable character, found in Colorado. The fossil calls to mind the wonderful but also extinct Sivatherium of the Sevalik Hills of India. The specimen corresponds with that portion of the face of the latter animal which comprises the upper part of the nose, together with the forehead and anterior horn cores. As in Sivatherium, all the bones comprising the specimen are completely coössified, and of great comparative massiveness. The genus was probably the American representative of the Sivatherium, which was the largest of all known ruminants. In its bulk and proportions it approached the elephant, and it was provided with two pair of horns and probably a proboscis like the taper.

Megacerops coloradensis.—The species was not so large as the *Sivatherium giganteum* of India, but may be regarded as having been the largest of all the known ruminants of America, recent and extinct.

ARTIODACTYLA.

Under this ordinal name the writer has included the thick-skinned animals or pachyderms of Cuvier, which have an even number of toes, and has excluded the ruminants of the artiodactyle pachyderms of Professor Owen.

SUIDÆ.

The suilline family at the present time is not represented in America by any of the old-world genera, nor at any past time, so far as the observation of the writer is concerned, was it inhabited by them. Notwithstanding many reports of discoveries of remains of the hog and the hippopotamus, the writer has as yet seen no undoubted traces of these animals which pertained to the American continents.

DICOTYLES.

The peccaries appear to have represented in the western hemisphere the hogs of the other part of the world; at least the writer has not yet seen fossil remains which appeared to him as indubitable evidences of the existence at any time of an indigenous species of hog in America. At the present time two species of peccary inhabit South America, and one of them, the collared peccary, extends into North America as far as the Red River in Arkansas.

At an earlier period several species, now extinct, inhabited North America. Professor Hayden found an upper canine tooth of a peccary on the Niobrara River, but its age and reference to a particular species are uncertain. A portion of a skull, found in digging a well, at the depth of thirty feet, in Gibson County, Indiana, indicates a species which has been named *Dicotyles nasutus*. It was rather larger than either of the existing species, and had a proportionately longer and narrower muzzle. Several teeth found in the miocene deposit of Monmouth County, New Jersey, I suspect to belong to the same.

A few remains found in Maryland, Virginia, and South Carolina apparently indicate a species smaller than the collared peccary. It has been named *Dicotyles lenis.*

PLATYGONUS.

This name has been given to an extinct genus of peccary-like animals which appear to have been abundant during the post-pliocene period. Numerous remains of a species, the *Platygonus compressus*, have been found in the lead-bearing crevices of the cliff limestone at Galena, Illinois. An entire skull, as fresh in appearance as if taken from a living animal, and of the same species, was discovered as early as 1805, in a cave in Kentucky. Remains have also been found in Iowa.

ELOTHERIUM.

This is an extinct genus of suilline animals, originally characterized by remains discovered in the miocene tertiary deposits of France, and was first described in 1847. Its nearest allies now living are the hog, the peccary,and the hippopotamus. The remains of two and perhaps three species of the genus have been found in the miocene deposits of the *mauvaises terres* of Dakota.

Elotherium Mortoni.—The remains from upwards of a dozen individuals of this species have come under the notice of the writer. It was about the size of the domestic hog. The skull bears some resemblance to that of the latter animal. Capacious temporal fossæ for the accommodation of powerful muscles, separated by a median crest, give the cranial portion of the skull a decidedly tiger-like aspect. The strong jaws are provided with a full series of seven molars, a canine, and three incisors on each side above and below.

The pointed character of the latter teeth, the long, bear-like canine teeth, and the conical premolars, probably indicate at least a partially-carnivorous habit. The true molars or grinders approach in character the corresponding teeth of the living suilline animals.

The species was named in honor of the late Dr. S. G. Morton.

Elotherium ingens.—The second species, about a third longer than the former, is founded on a few jaw fragments and teeth obtained by Professor Hayden in the *mauvaises terres.*

Elotherium superbus.—A third species, even larger than the former, indicated by an incisor tooth, from Douglas Flat, Calaveras County, California. The specimen was submitted to the writer by Professor J. D. Whitney.

PERCHŒRUS.

An extinct genus allied to the peccary. It is indicated by small fragments of jaws and teeth, from the miocene tertiary deposit of the *mauvaises terres* of White River.

Perchœrus probus.—The species thus designated was about the size of the living *Dicotyles labiatus* of South America.

LEPTOCHŒRUS.

Another extinct genus thus named is also allied to the peccaries. It is indicated by fragments of jaws and teeth found in association with those of the preceding animal.

Leptochœrus spectabilis.—This species was about the size of the collared peccary.

NANOHYUS

Is the name applied to another extinct genus of suilline animals, indicated by a lower-jaw fragment, from the same locality as the remains of the preceding two genera.

Nanohyus porcinus.—The species was about the size of the common rabbit.

MICROSUS.

A small suilline animal of an extinct genus, thus named, is inferred from a jaw fragment with teeth, obtained during the last expedition of Professor Hayden, on Black's Fork of Green River, near Fort Bridger, Wyoming.

Microsus cuspidatus.—The species named from the pointed condition of the tubercles of the teeth was about the size of the common rabbit.

HYOPSODUS.

A fragment of the lower jaw with teeth, found in association with the specimen last mentioned, appears to indicate a hitherto unknown genus to which the above name is given.

Hyopsodus paulus.—The species was about the size of a large hare.

Anoplotheridæ.

This ancient and extinct family is typified by the singular genus *Anoplotherium*, originally described by Cuvier, from remains obtained from the eocene formation of the Paris basin. In the earliest part of the tertiary period it appears to have been the genus which most nearly approached in character the ruminants of later epochs. In *Anoplotherium* the teeth formed closed series in both jaws, as we now observe to be the case in no mammals except man.

TITANOTHERIUM.

This genus is apparently allied to the *Anoplotherium* of Europe, and another extinct genus named *Chalicotherium*, whose remains were discovered in the Sevalik Hills of India.

Titanotherium prouti.—This species is established on remains of a huge animal, the largest of those yet indicated by the fossils obtained in the *mauvaises terres* of White River, Dakota. It approached in size the elephant, and it was no doubt the conspicuous size of its remains which led to its having been the first noticed of all the extinct animals whose bones have been collected in the *mauvaises terres* cemetery.

The first notice of it was published in 1846, by the late Dr. Hiram A. Prout, of St. Louis, who, from the character of the lower teeth, supposed it to belong to the genus *Palæotherium*, originally established by Cuvier from remains obtained from the eocene formation of Paris, France.

Many remains, consisting of fragments of jaws, teeth, and articular ends of different bones of the skeleton, collected by Messrs. Meek, Hayden, and Evans, indicate a nearer alliance of the animal to the companion of the Palœothere, that is to say, the Anoplothere.

The remains of the species, named in honor of its discoverer, Dr. Prout, belong to the lowest beds of the miocene deposits of the *mauvaises terres*, according to the authority of Professor Hayden.

The teeth of Prout's Titanothere formed nearly unbroken rows, though not so completely as in the Anopothere. It appears to have possessed an incisor less on each side than in the latter, and its canines were proportionately larger, differences which induced small breaks or intervals in the dental series. Among living animals, the grinding teeth of the Titanothere approached most nearly in appearance those of the rhinoceros. In the best preserved specimen of the jaws of Titanothere the series of teeth measure nearly a foot and a half in length.

Various fragments of the skeletons of different individuals indicate considerable variation in size, probably due to difference in sex.

Dr. John Evans reported the discovery of the skeleton of an individual imbedded in the rock in the *mauvaises terres*, which measured, in position, about eighteen feet in length and nine feet in height. This appears much too large in proportion to the size of the jaws above referred to, and the measurement is probably greatly exaggerated, if it, perhaps, does not apply to some other and larger animal. The specimens upon which the species *T. Prouti* is established indicate an animal intermediate in size to the Indian rhinoceros and the elephant.

PALÆOSYOPS.

This extinct genus is indicated by some remains obtained during Professor Hayden's last expedition. The specimens consisting of small fragments of jaws, with molar teeth, were found at Church Buttes, and on Henry's Fork of Green River, Wyoming. The remains belong to the Bridger Group of tertiary rocks, probably of miocene age. The genus is closely allied to *Titanotherium* of the *mauvaises terres*, and to *Chalicotherium* of the Sevalik Hills of India.

Palæosyops paludosus.—The only species of the genus approximated in size the common ox.

Anthracotheridæ.

This name has been given to an extinct family of even-toed pachyderms whose types are the genera *Anthracotherium* and *Chæropotamus*, of the early and medial tertiary formations of Europe. It is also represented in the miocene tertiary formation of the *mauvaises terres* of White River by the remains of a genus which had been previously recognized as occurring in England and France.

HYOPOTAMUS.

This genus was established by Professor Owen from some remains found in the eocene deposit of the Isle of Wight. The true molar teeth, or grinders, resemble those of ruminating animals, except that the upper ones present the remarkable character of an additional or fifth lobe introduced between the anterior pair of lobes. The whole number of teeth and the kind correspond with those of the existing hog.

Hyopotamus Americanus.—A species based upon fragments of jaws and teeth discovered by Professor Hayden, who refers them to the lowest bed of the tertiary formation of the *mauvaises terres*. The animal approached in size the common ox.

PERISSODACTYLA.

This name, originally employed by Professor Owen, I have used to include all the uneven-toed pachyderms of Cuvier, except the solidungulate or equine animals. Thus restricted, the order is represented by seven genera, in the tertiary formations of our Western States and Territories.

Rhinocerotidæ.

Among the most interesting paleontological discoveries in this country is that of the former existence of the rhinoceros family on the North American continent. Remains of a number of species have been detected in Dakota, Nebraska, Texas, California, Oregon, Colorado, Wyoming, and traces even in New Jersey.

RHINOCEROS.

The existing species of this genus are now confined to Asia and Africa. Remains of extinct species have been found in great abundance throughout Europe and Northern Asia. The living species are provided with one or two horns; some of the extinct ones were hornless, and have, on this account, been referred to a different genus, with the name of *Aceratherium.*

Rhinoceros occidentalis.—A hornless species, distinguished by the above name, and little more than half the size of the common Indian rhinoceros, is indicated by an abundance of remains in the miocene tertiary deposits of the *mauvaises terres*, of White River, Dakota. Its dentition is the same as in the living unicorn rhinoceroses; that is, it possesses two incisor and seven molar teeth on each side of both jaws.

The length of the skull of this species is one foot and a half.

Rhinoceros crassus.—This species, about the size of the Indian rhinoceros, is indicated by a few fragments of jaws and teeth discovered by Professor Hayden in the pliocene sands of the Niobrara River, Nebraska.

Rhinoceros meridianus.—A third species, intermediate in size with the two former, is indicated by an imperfect molar tooth, discovered by the late Dr. B. F. Shumard in a tertiary formation of Washington County, Texas.

Rhinoceros hesperius.—A fourth species, under this name, has been viewed as distinct from the former ones, and was founded on specimens submitted to the writer by Professor J. D. Whitney. The specimens, consisting of the greater portion of a lower jaw with the teeth, and some fragments of upper molars, were derived from a tertiary deposit of Calaveras County, California. The species was about the size of the *R occidentalis* of the *mauvaises terres.*

Recently some remains, probably of the same species, were sent to the writer for examination by the Rev. Thomas Condon, who obtained them on the John Day River, Oregon.

HYRACODON.

This genus has been proposed by the writer, founded on abundance of remains of a small rhinoceros, which differs from all others previously described, whether recent or extinct, in the possession of canines and a full series of incisors in both jaws. The genus was also hornless.

Hyracodon nebrascensis.—The only species of the genus indicated was the smallest of its American kindred, and was about the size of the little hippopotamus of Liberia, Western Africa. During the miocene period it existed in great numbers, associated with the *R. occidentalis*, as proved by the abundance of its remains in the *mauvaises terres* deposits. Remains, apparently of the same species, have been discovered in Colorado, Wyoming, and Oregon. The skull of *H. nebrascensis* is about ten inches in length.

HYRACHYUS.

An extinct genus, allied to *Hyracodon*, is founded on a fragment of a lower jaw of a young animal, obtained, during Professor Hayden's recent expedition, on Black's Fork of Green River, Wyoming. In the mature animal seven molar teeth formed a continuous series in the jaws. The upper molars are unknown. The lower true molars resemble those of *Hyracodon*, but the crowns have their constituent lobes more deeply separated externally by an angular notch. The premolars in comparison with the true molars are proportionately smaller than in *Hyracodon.*

Hyrachyus agrestis.—The species was smaller than *Hyracodon nebrascensis*, and was about the size of the larger living peccary. The molar series occupied a space of about three inches. The first premolar has a laterally-compressed conical crown spreading in a slight posterior heel.

Hyrachyus agrarius.—A supposed second species, probably of the same genus, is inferred from the portion of a lower jaw about the size and form of the corresponding part in *Hyracodon nebrascensis.* The specimen was obtained on Smith's Fork of Green River, Wyoming. The jaw below the last molar is about an inch and three-fourths deep. Its ascending portion in front rises vertically, and externally is deeply concave. The molar series, consisting of seven teeth, is broken away in the specimen. The space occupied by the series is about three inches and three-fourths. The true molars occupied a space of full two inches.

Tapiridæ.

The existing members of the tapir family in this part of the world are confined to Central and South America. During the quaternary period, contemporaneously with the well-known mastodon, several species of tapir inhabited North America.

LOPHIODON.

An extinct genus, described under the above name, by Cuvier, from remains found in the middle tertiary formations of Europe, appears also to have existed contemporaneously in North America.

Lophiodon occidentalis.—A species, about the size of the common tapir (*T. terrestris*) of South America, is indicated by a single tooth discovered by Professor Hayden in the *mauvaises terres* of White River. A fragment of an upper jaw, with two teeth, obtained by the Rev. Thomas Condon, from Bridge Creek, Oregon, is perhaps referable to the same species.

Lophiodon modestus.—A small species of the same genus, thus named, is indicated by a single tooth, discovered in Professor Hayden's last expedition, near Fort Bridger, Wyoming.

LOPHIOTHERIUM.

An extinct genus of this name, described by Professor Gervais, from remains found in the eocene formation of France, appears also to have been represented by a small species during the formation of the Bridger Group of tertiary deposits.

Lophiotherium sylvaticum.—The species is indicated by a jaw fragment with teeth, obtained during Professor Hayden's last expedition on Henry's Fork of Green River, Wyoming. The animal was about two-thirds the size of the collared peccary.

Proboscideæ.

Of all extinct animals none are more familiar to the community than the great proboscideans. Their huge bones, strewed over the earth, have excited the attention of the least observant, and in former years were viewed as unmistakable evidences of the earlier existence of a race of giant men. Even now, to the uninformed their remains have not ceased to be objects of wonder and the most convincing proofs that in former ages huge animals roamed over the country where now they no longer exist.

MASTODON.

This extinct genus of elephants appears to have once lived throughout the greater part of the world. A half dozen species inhabited Europe, the same number Asia, two South America, and at least three, if not four or five, North America.

Mastodon americanus.—The great American mastodon appears to have extended throughout the whole of North America during the quaternary period. Its remains are among the most abundant of fossils and have been found in almost every state and territory of the United States. Complete skeletons, together with skulls of others, in a fine state of preservation, are among the most conspicuous and striking objects of several of our museums. It is probable that this species still continued to exist at the time of man's appearance on the stage of life.

Mastodon mirificus.—This species, whose remains were first discovered by Professor Hayden, on the Loup Fork of the Niobrara River, lived at an earlier period than the preceding, pertaining, as supposed, to the pliocene age. It was about the size of the common mastodon.

Mastodon Shepardi.—A third species, probably of miocene age, has been recently characterized from a fragment of a tusk, from Stanislaus County, California. The tusk of the common American mastodon is composed alone of ivory, as in the modern elephants; but the fragment just alluded to presents a broad band of enamel, as in the tusks of the narrow-toothed mastodon of the miocene formation of Europe. The species is named in honor of Professor C. U. Shepard, of Amherst College, by whom the fossil was submitted to the writer.

Mastodon obscurus.—This name has been appropriated to a supposed species, founded on a tooth which was reported to have been discovered in the miocene deposit of Maryland. Fragments of similar teeth from North Carolina and Georgia appear to confirm the distinctness of this species from *M. americanus* and *M. mirificus.* A portion of a lower jaw containing a last molar, like the Maryland tooth, was recently discovered in Contra Costa County, California. This specimen also clearly distinguishes the species from those just named, but we have no evidence to prove that it is not identical with the *M. Shepardi.*

ELEPHAS.

The most colossal of all terrestrial animals, the elephants, are now confined to Southern Asia and Africa. Prior to the *actual* period species existed in Asia, Europe, and North America which are now extinct.

Elephas americanus.—Remains of an extinct species of elephant have been discovered throughout the greater part of the North American Continent. Generally these remains have been viewed as pertaining to the *Elephas primigenius*, an extinct species of Europe and Northern Asia, and which probably also extended into the extreme northwest of North America. There appear now to be sufficient grounds to consider the American elephant a distinct species from the one just named. The late Dr. Falconer, of England, who perhaps more than any one else had studied the characters of the elephant family, supposed that among the remains found throughout North America there were evidences of two species, one of which he called *Elephas columbi*, and the other he viewed as the *E. primigenius.* The writer also thought he recognized a different species from the common one in some remains obtained by Professor Hayden on the Niobrara River. Upon a review of all the material pertaining to the subject, he now considers that the remains of North America, which have been referred to several species of elephant, belong to but one, distinguished by the name heading this article.

SOLIDUNGULA.

This order is now represented by the single genus Equus, of which no living species is indigenous to America. Fossil remains go to show that during earlier geological periods the order was nowhere so well represented as it was in America. The members of the order are divisible into two groups or families, which have been named the *Equidæ* and the *Anchitheridæ.*

Equidæ.

The equine family is represented at this time by nine or ten species of equus, which appear all to be indigenous to Asia and Africa. Other species of the same genus inhabited Europe, Asia, and North America during the middle and later tertiary periods extending into the quaternary period.

EQUUS.

Though no indigenous species of horse appears to have existed on the American continent during the period of man, a number of them inhabited the country just previously and contemporaneously with the great mastodon, the elephant, the giant sloths of both North and South America, &c. Dr. Lund and Professor Owen have indicated several species from remains found in the latter continent. A number of species have likewise been indicated from remains pertaining to the pliocene and quaternary deposits of North America.

Equus fossilis.—This name has been appropriated to a species whose remains are found in the quaternary deposits of Europe and Northern Asia.

By many the species is supposed to have been the ancestor of the common domestic horse. A few remains found in the frozen cliffs of Eschscholtz Bay, Alaska, in association with remains of the extinct northern Asiatic elephant, are supposed to belong to the same species.

Equus major.—Remains of a species of horse have been discovered in the United States, in association with those of the mastodon, &c. The arrangement of the enamel folding in the upper molar teeth is of a more complex character than in the domestic horse. The species was larger than ordinary varieties of the latter, which led to its being named *Equus major*, though it did not exceed in size the English dray horse.

Equus fraternus.—This name has been proposed for a second species, based on remains found in association with those of the former, together with those of the mastodon, &c., although they are neither distinguishable in size nor details of form from corresponding parts in the domestic horse.

Equus excelsus.—A third species, whose remains are found in the pliocene deposits of the Niobrara River, was about the size of the domestic horse. Its remains have also been found in California and Oregon. The grinders of this species differed in the arrangement of their enamel from those of the domestic horse in the same manner as do those of the ass.

Equus pacificus.—Another species, indicated by remains from California, was about the size of the English dray horse. The arrangement of the enamel folds of its molar teeth is of the utmost comparative simplicity.

Equus parvulus.—This name has been assigned to a supposed diminutive species, by Professor Marsh, on some remains found in a tertiary deposit of Antelope Station, Nebraska, four hundred and fifty miles west of Omaha. It probably pertained to the succeeding genus.

Equus conversidens—*Equus tau.*—These are the names of two species recently indicated by Professor Owen, of London, from remains discovered in the tertiary deposits of the valley of Mexico.

PROTOHIPPUS.

An extinct genus of equine animals, distinguished by the above name, was originally characterized from remains discovered by Professor Hayden in the pliocene sands of the Niobrara River. Remains of the same genus have likewise been found in South America, but were referred to species of the former genus by Dr. Lund and Professor Gervais. Professor Owen, recognizing their distinction, has recently referred them to a different genus with the name of *Hippidion*. The remains from the Niobrara River indicate three species of the genus, all of which were smaller than the domestic horse.

Protohippus perditus.—This species approximated in size the ass.

Protohippus placidus.—This second species was not more than two-thirds the size of the former one.

Protohippus supremus.—A third species, intermediate in size to the ass and the domestic horse, is indicated by some remains, found by Professor Hayden in 1866, on the Little White River, or the South Fork of White River, Dakota.

The South American species of the genus have been named *Protohippus arcidens*, *P. principalis*, and *P. neogæus*.

HIPPARION.

This is the name of an extinct genus of equine animals, whose remains have been found in the middle and later tertiary deposits of Europe, Asia, and North America. The skeleton was constructed on the same general plan as in the preceding genera, but in addition to the well-developed toe or hoof, which supported the animal, it possessed an additional pair of toes to each foot. These, however, were not sufficiently developed to touch the ground, but projected behind and laterally like the rudimental toes of hogs and ruminants. The arrangement of the enamel in the molar teeth is of a more complex character than in *Equus* and *Protohippus.* A species is indicated by remains found in the Ashley River deposits of Charleston, South Carolina. It was not more than about half the size of the ass, and has been named *Hipparion venustum.*

Hipparion occidentale.—This species, about the size of an ass, is indicated by remains which were found in the *mauvaises terres* of White River, Dakota; but which clearly do not belong to the miocene formation of that region. They pertain to a superficial portion of the tertiary deposit, cotemporaneous with the pliocene deposits of the Niobrara River.

Hipparion speciosum.—A supposed second species, nearly the same size as the preceding, is indicated by molar teeth found at Bijou Hill, on the Missouri River, and in the pliocene sands of the Niobrara River. A fragment of a tooth, likewise apparently belonging to this species, was found in digging a well, at the depth of forty feet, in Washington County, Texas.

Hipparion affine.—A third species, also about the same size as the preceding, is indicated by teeth discovered by Professor Hayden in the pliocene sands of the Niobrara River. The enamel folding of the upper grinders is of a simpler character than in the former species.

Hipparion gratum.—This species, based upon a number of teeth obtained by Professor Hayden in the pliocene sands of the Niobrara River, was considerably smaller than the other species with which it was associated.

MERYCHIPPUS.

Another extinct equine genus, has permanent molar teeth like those of *Protohippus*, but the skull presents deep lachrymal depressions in advance of the orbit, as appears also to be the case in *Hipparion*, but which, in the former, as in the true horse, are absent. The temporary teeth of *Merychippus* resemble more nearly in appearance the permanent ones of the members of the next family than they do those of the other known equine genera. It was from the remarkable resemblance of these to the large grinders of ruminating animals that led to the adoption of the name of *Merychippus*, which literally signifies ruminating horse. The name, however, refers to the resemblance alone, and does not indicate that the animal partook of the peculiar habits of the ruminants.

Merychippus insignis.—This species, about the size of the ass, was originally established on a jaw fragment, containing teeth, which was discovered by Professor Hayden at Bijou Hill. Many additional remains, referable to the same species, were subsequently found in the pliocene sands of the Niobrara River, during Warren's expedition in 1857.

Merychippus mirabilis.—This second species, rather larger than the preceding, is indicated by remains discovered by Professor Hayden in the pliocene sands of the Niobrara River and on Little White River, Dakota.

Anchitheridæ.

This extinct family of three-toed, horse-like animals, has for its type the genus *Anchitherium*, the first known species of which was described by Cuvier under the name of *Palæotherium aurelianense.* Its remains were obtained from the miocene tertiary deposits of France. Lartet and DeBlainville call the same animal *Palæotherium hippoides*, or horse-like Palæothere.

In the *Equine* family the teeth have long crowns, which are gradually protruded as they are worn away; in the *Anchitherine* family the teeth have comparatively short crowns, which are quickly protruded and inserted into the jaws by long fangs. Their skeleton in general form closely approximates that of the horse, and most nearly that of *Hipparion.*

ANCHITHERIUM.

This genus is represented in the miocene deposits of our Western Territories by two species.

Anchitherium Bairdi.—The remains of this species are comparatively abundant, in association with those of oreodons, rhinoceros, &c., in the *mauvaises terres* of White River, Dakota. The skull of the species is a miniature form of that of the horse, except that the face is proportionately shallower. Its length is rather less than seven inches. The size of the animal was about half that of the domestic horse. The species was named in honor of Professor Baird, of the Smithsonian Institution.

Anchitherium Condoni.—A second species is inferred to have existed from a fragment of an upper jaw with a mutilated tooth, discovered by the Rev. Thomas Condon, of Dalles City, on Bridge Creek, a tributary of John Day's River, Oregon. It was rather larger than the preceding species, and is named in honor of its discoverer.

HYPOHIPPUS.

An extinct genus to which this name is given is represented by the following species:

Hypohippus affinis.—Established on a single tooth, indicating an animal about the size of the domestic horse.

ANCHIPPUS.

Another extinct genus, allied to the preceding, is represented by the following species:

Anchippus texanus.—The species is established on a molar tooth obtained by the late Dr. Shumard in Washington County, Texas. It was found in digging a well at the depth of 50 feet in a sandstone supposed to be of miocene age. The animal indicated by the tooth was rather smaller than the ass.

PARAHIPPUS.

A fourth genus of the extinct *Anchitherine* family, named as above, is indicated by some teeth discovered by Professor Hayden in the pliocene sands of the Niobrara River. The teeth resemble in their characters those of *Anchitherium* more nearly than they do those of any of the equine genera; nevertheless they exhibit more complexity than in the former or any other member of the same family.

Parahippus cognatus.—The species thus designated is established upon an incomplete series of well-preserved teeth. The animal was about a third less in size than the ass.

RODENTIA.

The order of gnawing animals is represented in the tertiary formations of the West by half a dozen genera, most of which are extinct. The comparative smallness of the animals of this order renders their remains more liable to total destruction than those of larger animals, and also to their escaping notice when preserved. No doubt many remains of unknown species and genera will be discovered in future explorations of the tertiary deposits.

Leporidæ.

The hare family is represented in the miocene formation of the *mauvaises terres* by a peculiar genus, which probably was the remote ancestor of our rabbits.

PALÆOLAGUS.

The genus is established on a number of fragments of jaws and teeth discovered by Professor Hayden at the head of Bear Creek, a tributary of the Sheyenne River, Dakota. Palæolagus had the same number of teeth as in the rabbit, but the first lower molar is composed of a double column, as in the other molars, whereas in the latter it has an additional column.

Palæolagus Haydeni.—The species, named in honor of its discoverer, was rather less in size than our common gray rabbit.

Sciuridæ.

The family of the squirrels and marmots was represented by a peculiar genus, whose remains were discovered by Professor Hayden in association with those of the former. Similar remains were subsequently obtained from the *mauvaises terres* of White River. The genus is distinguished by the following name:

ISCHYROMYS.

The skull of the genus approaches most nearly in form that of the living beaver, but the teeth more nearly resemble those of the squirrel.

Ischyromys typus.—The species was about the size of the common muskrat.

Castoridæ.

The beaver family is represented both in the miocene and pliocene formations of Dakota and Nebraska.

PALÆOCASTOR.

A rodent or gnawer, to which this name is given, is founded on several incomplete skulls, together with a number of fragments of jaws with teeth, obtained by Professor Hayden in the miocene deposit of the *mauvaises terres* of White River, Dakota.

Palæocastor nebrascensis.—The species was about half the size of the existing beaver.

CASTOR.

The sole representatives of this genus now living are the American and the European beaver.

Castor tortus.—An extinct species, thus named, is indicated by a portion of a skull, with teeth, found by Professor Hayden in the pliocene sands of the Niobrara River. It was only half the size of the living species.

Muridæ.

The rat family is represented in the miocene deposit of the *mauvaises terres* of White River by an extinct genus, to which the following name has been applied:

EUMYS.

This genus is founded upon the fragment of a jaw discovered by Professor Hayden.

Eumys elegans.—The species was about the size of the brown rat.

Hystricidæ.

The porcupine family is represented by a species whose remains were found by Professor Hayden in the pliocene sands of the Niobrara River.

HYSTRIX.

The living species of this genus are confined to the Old World, none having been discovered in America.

Hystrix venustus.—An extinct species, indicated by several isolated teeth from the Niobrara River. Judging from the characters of the teeth it was more nearly related with the crested porcupine of Europe than with our own living porcupine, pertaining to another genus.

INSECTIVORA.

The insectivorous order of animals, mainly consisting of the smallest forms of the mammalian class, as might be supposed, are among the rarest of those whose remains are found preserved in fossiliferous strata. Professor Hayden's explorations in the West have led to the discovery of three extinct genera of the order, pertaining to the miocene tertiary formation of the *mauvaises terres* of White River, Dakota, and a third genus was discovered by Dr. J. Van A. Carter, of Fort Bridger, Wyoming, in the Bridger Group of tertiary deposits of his vicinity.

LEPTICTIS.

The genus to which this name is given is established on the specimen of an almost complete skull, which was found imbedded in a soft rock near the mouth of one of the small tributaries of White River, in the *mauvaises terres.* It possessed three incisor, a canine, and seven molar teeth on each side of the jaws. The top of the skull presents a pair of prominent ridges, defining the temporal fossæ. The animal was allied more nearly to the hedgehogs than to any other of the living members of the order.

Leptictis Haydeni.—The species, named in honor of its discoverer, was scarcely as large as a mink. The skull is barely two and a half inches long.

ICTOPS.

A second genus, closely allied to the preceding, is indicated by a small fragment of a skull, found in association with the former specimen. It is distinguishable from it by difference in the form of the molar teeth.

Ictops dakotensis.—A species about the same size as the preceding, with which it lived cotemporaneously.

OMOMYS.

This extinct genus, probably pertaining to the same family as the European hedgehog, was established on the fragment of a lower jaw, with teeth, from the tertiary formation near Fort Bridger, Wyoming.

Omomys Carteri.—The species, named in honor of its discoverer, was about half as large again as our common mole, (*Scalops aquaticus.*)

EDENTATA.

Among the great multitude of vertebrate fossils brought to our notice from the western part of the continent, we have detected almost no traces of remains of the giant sloths, which existed so extensively during the quaternary period in both North and South America. Remains of *Mylodon Harlani* have been found on the Willamette River, Oregon, and recently we have seen the fragment of a claw phalanx, apparently of a large, sloth-like animal, from Castle Creek, Idaho.

CETACEA.

Remains of cetaceans, thus far, have been but sparingly found in the tertiary and quaternary formations of the West. Vertebræ from the later deposits have been indicated from Oregon.

DELPHINUS.

Remains of porpoises have been discovered in the upper miocene formation of Half-Moon Bay, California.

Delphinus occiduus.—A species, founded upon a jaw fragment from the locality just named, submitted to the examination of the writer by Professor J. D. Whitney. It was about the size of our common porpoise.

BIRDS.

The remains of birds are among the rarest of vertebrate fossils in most of the explored rocks of the world. From the peculiarities of these animals, enabling them to escape many of the catastrophes or accidents to which more terrestrial and aquatic animals would be liable, and from the generally lighter construction of their bodies, they are less likely to be placed in positions where their remains would be preserved and become fossils. Among the large collections of fossils made in the *mauvaises terres* of White River, Dakota, amounting to several tons in weight, which have been submitted to the writer's examination, he discovered no trace of birds. In all other collections from the West there was likewise no trace detected, except a single bone fragment discovered by Dr. Hayden in the pliocene sands of the Niobrara River, Nebraska. This specimen has been recently described by Professor O. C. Marsh, who views it as pertaining to an extinct species, to which he has given the name of *Grus Haydeni.*

REPTILES.

The remains of reptiles occur in the greatest abundance in the secondary formations of the West. Those best known have been derived from the cretaceous deposits of Kansas, Dakota, and of the head-waters of the Missouri River. Remains of the same order, though less abundant, are nevertheless quite numerous in the tertiary deposits of the country, especially those of turtles.

CHELONIA.

The chelonians or turtles appear to have been exceedingly abundant in the West during the tertiary period. They, however, appear not to have been so rich in the number of genera and species relatively as they do in the multitude of individuals of a few genera and species. Their remains are found in association with the numerous mammalian fossils of the *mauvaises terres* of Dakota and those of the Niobrara River. A greater number of species and genera are indicated by the remains in the tertiary deposits of the vicinity of Fort Bridger, Wyoming.

EMYS.

The genus emys includes many of our living fresh-water terrapenes, and is also represented in Europe and Asia. It has latterly been divided into different genera, founded on characters of the jaws, head, and feet; so that from the fossil shells alone we are unable more distinctly to define the animals. The shell of emys is rather oval in outline, moderately convex. The sternum is large, truncated in front, and notched behind. Its broad pedicles are joined by firm suture to the upper shell or carapace. The outer portions of the humeral and abdominal scutes cover these pedicles, and join the marginal scutes between the position of the axillary and inguinal scutes.

Emys Jeanesi.—This species is founded on a nearly complete shell, obtained, during Professor Hayden's last expedition, from the tertiary deposit of the Bridger Group, near Fort Bridger, Wyoming. The length of the shell, following the fore-and-aft curve, is fifteen inches; the length of the sternum is about one foot. The species is named in honor of Joseph Jeanes, to whose aid we have been much indebted in developing the fossil treasures of the West.

Emys Haydeni.—A second species has been inferred to have existed from an imperfect shell found in association with the former specimen, together with many fragments of shells of the same and other species of turtles. The species was about the size of the last, but is distinguished from it by the difference of form of its scute impressions.

Emys Stevensoni.—An apparent third species is founded on fragments of the carapace and sternum of a shell, obtained by Dr. J. Van A. Carter, from the tertiary deposit in the vicinity of Fort Bridger, Wyoming. It has been named in honor of James Stevenson, the active and efficient aid of Professor Hayden in his explorations.

STYLEMYS.

By this name the writer has distinguished an extinct genus of turtles, which is intermediate in form between the modern land turtles (*Testudo*) and the aquatic ones (*Emys.*) As in the former the back extremity of the carapace is invested with a broad, symmetrical plate, instead of a pair, as in the latter.

Stylemys nebrascensis.—The species is established upon specimens which have been collected by every explorer of the *mauvaises terres* of White River, Dakota. So abundant have these fossil turtles been in the locality mentioned that they have attracted the attention of the most indifferent observers. Among the specimens submitted to the examination of the author, considerable variation has been noticed, and this variation at first led to the distinction of five different species. At present he views them all as belonging to but one species. Several mature specimens measure one and three-quarter feet in length by one foot and a quarter in breadth.

Stylemys niobrarensis.—A second species has been supposed to exist, founded on a multitude of fragments, discovered by Professor Hayden in association with mammalian remains in the pliocene sands of the Niobrara River. It was as large as the preceding species.

BAPTEMYS.

An extinct genus of terrapenes, thus named, is established on an almost perfect shell, obtained from the miocene tertiary deposits in the vicinity of Fort Bridger, Wyoming. It was submitted to our examination by Mr. O. C. Smith of Amherst, Massachusetts. The genus approaches in character the existing *Dermatemys* of Central America. The pedicles of the sternum are covered by a large scute intervening between the comparatively large inguinal and axillary scutes, and separating the humeral and abdominal scutes from the marginal ones.

Baptemys wyomingensis.—The shell of the species measured about one foot and a half in length by a foot in breadth.

BÆNA.

Another extinct genus of turtles is indicated by two nearly complete shells, obtained from the tertiary formation near Fort Bridger, Wyoming. One of the specimens was discovered during Professor Hayden's last expedition; the other was presented to the writer by Dr. J. Van A. Carter, of Fort Bridger. The genus partakes of characters of the terrapenes and the snappers. The shell is moderately convex as in the latter, and like it is notched at the sides posteriorly. The sternum is more like that of the emydes than of the snappers. The sternal pedicles are deep and wide, and are impressed by one or two large scales intervening between the humeral and abdominal and the marginal scutes, and separating comparatively large axillary and inguinal scutes.

Bæna arenosa.—In its perfect condition the shell measured about fourteen inches long and about ten and a half wide. Two large scutes intervene to the axillary and inguinal scutes.

Bæna affinis.—This may, perhaps, be the same as the former. It was nearly of the same size and shape, but in the specimen which has suggested the idea of a species distinct from the former, a single accessory scute intervenes to the axillary and inguinal scutes.

TRIONYX.

The genus of soft-shelled turtles is represented by a number of extinct species belonging to both the secondary and tertiary formations of this country. Numerous fragments, in the collections of fossils obtained by Dr. J. Van A. Carter, and in those made during Professor Hayden's last two expeditions, from the tertiary deposits of Wyoming, apparently indicate two extinct species. Only one of these, however, can be characterized from the more perfect of the specimens.

Trionyx guttatus.—This species is established on a large portion of a carapace, discovered by Professor Hayden in 1868, at Church Buttes, near Fort Bridger, Wyoming. The shell of the animal was about a foot and a quarter long by a foot in breadth.

CROCODILIA.

Remains of crocodilians have not been found so abundantly in the West as might have been supposed. None have thus far been found among the multitude of other reptilian remains in the cretaceous formations of Kansas and Dakota. None have been discovered in the miocene tertiary deposits of the *mauvaises terres* of Dakota, nor the pliocene sands of the Niobrara River. One would have suspected that crocodiles would have been abundant where there were such vast numbers of mammals feeding in the vicinity of streams and lakes of fresh water, such as existed in Dakota and Nebraska during the tertiary period.

CROCODILUS.

Remains of this genus occur abundantly in the Bridger Group of tertiary formations in Wyoming. Among numerous fossils from this region sent to the writer by Dr. J. Van A. Carter, and in the collection made during Professor Hayden's last expedition, the writer has detected the remains of three species of crocodile.

Crocodilus aptus.—A species named from a single vertebra found by Colonel John A. Knight, United States Army, near South Bitter Creek, Wyoming. The animal was about the size of the Mississippi alligator. Remains apparently of the same species have been collected by Dr. J. Van A. Carter in the vicinity of Fort Bridger.

Crocodilus Elliotti.—The remains of a second species of crocodile were found in abundance, during Professor Hayden's last expedition, on one of the tributaries of Green River, Wyoming. The skull is about a foot and a half in length and bears a resemblance in shape to that of the crocodile of the Nile. The species is named in honor of Mr. Henry W. Elliott, the artist attendant on Professor Hayden's expedition. The remains of a third and smaller species of crocodile are contained in the collections made by Professor Hayden's party in the tertiary deposits of the Bridger Group. Dr. J. Van A. Carter has also sent to the author, from the same locality, a number of vertebræ of this third species.

LACERTILIA.

The cretaceous formations of the West teem with the fossil evidences of lacertilian life, forms well expressed in the line "there were giants in those days." These were, however, in many respects so peculiar, or different from the lacertilians of our day, holding as they did a position between the latter and the serpents, that Professor Cope has viewed them as characteristic of a distinct order, under the name of *Pythonomorpha.* The true lacertilians appear also to have been represented during the tertiary period, as indicated by the following genus:

SANIVA.

An extinct genus of lacertian reptiles, with the above name, is founded on remains discovered during Professor Hayden's last expedition, in a tertiary rock at Granger, Wyoming. The vertebræ, as in the living iguanas, monitors, &c., have the body excavated in a cup in front and terminating in a ball behind. The cup and ball are oblique and widest transversely. The animal possessed well-developed limbs with long toes, but the remains are too imperfect to determine their number and arrangement. The teeth were compressed, conical, and doubly trenchant, indicating carnivorous habits.

Saniva ensidens.—The species was as large as our largest living iguanas.

FISHES.

Numerous remains of fishes have been discovered in the secondary and tertiary formations of the West. Those from the secondary formations of cretaceous age belong to marine forms. Those of the tertiary formations of California, which have been described, also belong to marine forms, mainly sharks. Those of the tertiary formations east of the Rocky Mountains, which have been described, are from Green River, Wyoming, and Castle Creek, Idaho, and belong to fresh-water forms.

Cyprinidæ.

This is an extensive family of fresh-water fishes, among the least carnivorous of its class. It includes the carp, the gold-fish, the sucker, &c. It is well represented by the remains of a number of extinct species and genera in the tertiary deposit of Castle Creek, Idaho.

MYLOCYPRINUS.

An extinct genus, founded on numerous specimens of pharyngeal bones, supporting strong grinding teeth, submitted to the investigation of the author by Professor John S. Newberry.

Mylocyprinus robustus.—The large size of the pharyngeal bones with their robust grinders, looking like human premolar teeth, indicate a species several feet in length.

Cyprinodontidæ.

The living members of the cyprinodont family are small fishes, for the most part inhabiting fresh water.

CYPRINODON.

This genus is represented by an abundance of remains, discovered, in association with those of herrings, by Professor Hayden, in the tertiary shales of Green River, Wyoming.

Cyprinodon Levatus.—A small species, described by Professor Cope, from specimens obtained from the locality just named.

Clupeidæ.

The clupeoid family includes shad, herring, &c.

CLUPEA.

Several species of herrings have left an abundance of remains in the tertiary shales of Green River, Wyoming. The first of these fossils was made known to us in 1856 by the late Dr. John Evans.

Clupea humilis.—This species is about three and a half inches in length.

Clupea pusilla.—A species about half the size of the preceding and found with it described by Professor Cope.

Squammipennes.

A family of fishes characterized by the extension of scales on the fins. To it belongs the curious *Chætodon rostratus* of Java, which possesses the faculty of throwing a drop of water from its mouth, at an insect, with unerring accuracy.

ASINEOPS.

An extinct genus, established by Professor Cope on abundance of remains obtained by Professor Hayden in the tertiary shales of Green River, Wyoming.

Asincops squamifrons.—The species is about eight inches in length.

PLAGOSTOMI.

This order includes the sharks and rays.

SELACHII.

The selachians, or sharks, have left a multitude of remains in some of the marine tertiary formations of the West. From the miocene deposits of Ocoya Creek, at the western base of the Sierra Nevada, California, a number of genera and species have been indicated by Professor Agassiz, as follows: *Echinorhinus Blakei*, *Scymnus occidentalis*, *Galeocerdo productus*, *Prionodon antiquus*, *Hemipristis heteropleurus*, *Carcharodon rectus*, *Oxyrhina plana*, *Oxyrhina tumula*, *Lamna clavata*, *Lamna ornata*.

BATIDES.

The skates are indicated in the Ocoya Creek tertiary by the fragment of a tooth referred by Professor Agassiz to the genus *Zygobates*.

ONCOBATIS.

An extinct genus of rays is indicated by an osseous scale of peculiar character, from the tertiary deposit of Castle Creek, Idaho.

Oncobatis pentagonus.

The scale upon which the species is founded was discovered in association with abundance of remains of cyprinoid fishes, and is interesting as indicating most probably a large form which inhabited fresh water.

V.—ON THE FOSSIL PLANTS OF THE CRETACEOUS AND TERTIARY FORMATIONS OF KANSAS AND NEBRASKA.

BY L. LESQUEREUX.

CHAPTER I.

ON THE MODE OF PRESERVATION OF THE FOSSIL PLANTS, AND ON THE CIRCUMSTANCES UNDER WHICH THEIR FOSSILIZATION HAS BEEN EFFECTED.

Researches for fossil plants are, in this country, so rarely undertaken under a scientific direction, that their discovery is mostly a matter of chance, giving rise to speculations and queries of a most extraordinary kind. Not only our flexuous stems of *Stigmaria* have been often considered as snakes of a prodigious size, but many times in my explorations I have been amused by preposterous questions like this one, addressed to me by people, who, recognizing a branch of fern upon a specimen of shale of the coal, wished me to explain "by what means plants of such slender size could pierce the stones and grow into them." It is not, therefore, inopportune to say a few words on the questions heading this chapter.

Every kind of woody tissue, when shut out of atmospheric influence, (or of oxidation,) either by water or by any other matter, escapes decomposition for an indefinite length of time. In such circumstances, the wood is subjected to a slow kind of combustion, of which the first state is a softening of the tissue or of the whole mass. Timber used as piling in water or in clay is found, after centuries, blackened, and more or less plastic, without any trace of decay. Whole forests of the pliocene age have been imbedded in clay, or submerged, and the trees have now their tissues as soft as the clay itself, though their structure is in a perfect state of preservation. It is the same with some deposits of lignites of the tertiary, which are a mere compound of heaped trunks of trees whose wood has become black as coal, but is still soft as clay. This first mode of decomposition of the woody tissue explains the various appearances remarked in different kinds of fossil wood after complete mineralization; for it is easy to understand that, after this softening process, the wood is easily penetrated by different mineralizing elements, of which the water or the imbedding substances are impregnated. Some substances, especially lime and silica, do not destroy the woody tissue in penetrating it. The internal structure of fossil trees of this kind can therefore be studied in obtaining their lamellæ, and observing them with the microscope. This has furnished the means of exactly determining, if not the species, at least the genera to which are referable fossil trees of various geological epochs.

Deposits of fossil wood of this kind are generally formed in connection with our tertiary and cretaceous formations, and also, though more rarely, in our carboniferous measures. There is a deposit of silicified trunks in Southern Ohio, from which splendid specimens have been obtained. Silicified trunks of the tertiary are now found strewn on the sandy surface of the land in Mississippi, Arkansas, and farther west. This mode of petrification has happened to trees in a standing position as well as to prostrated trunks. In the first case the petrification of the trees is generally homogeneous or unmixed. In prostrated trunks the difference in the decomposition of the trees, at the time when they were buried, has apparently varied the mode and the agents of mineralization in such a way that, in the same specimens, part of a trunk is impregnated with lime, while other parts are silicified, and still others penetrated with oxide of iron or hardened into clay. Trees fossilized in that way have been remarked at various places, especially in beds of sandstone of the coal formations near Gallipolis, Ohio. At first it seems difficult to explain how trees can have been preserved in a standing position for a time long enough to produce mineralization. But in examining the geological strata of our coal measures, for example, it becomes evident that at repeated times, areas, sometimes of wide extent, have been subjected to great depressions, and been covered more or less rapidly with water and with the materials brought with it, especially sand. In that way entire forests have been buried, their trees imbedded to a certain height and petrified in that position, sustained as they were in their softened state by the imbedding materials. Such fossil standing trees are of no rare occurrence in the sandstone of our coal measures, and sometimes, as for example near Carbondale, Pennsylvania, the miners have pierced their tunnels through such forests of stone and brought to light an immense amount of their débris.

It is questionable if, by the petrification of trees by silex, the silica which has penetrated them was naturally in solution in the water covering the deposit, as Professor Gœppert will have it; or if, according to Professor Schimper's opinion, the silicification has happened only under the influence of hot springs, impregnated with a large proportion of silica, like springs of volcanic agency. The first or natural process can have been but very slow, and so long, according to Professor Schimper, that the wood could not have escaped total decomposition and destruction before its mineralization. In this assertion the celebrated professor is certainly in error, for, from what we have said before, the woody tissue, protected by immersion against the destroying influence of the oxygen of air, is indeed indestructible for an indefinite length of time; and being preserved for whole epochs in the soft state, can be thus slowly impregnated by any kind of mineralizing elements which may be in solution in the water. The opinion of Professor Schimper is still contradicted by the fact that in this country silicified wood is found in our coal measures and in our tertiary and cretaceous formations in connection with such strata, which do not show the slightest traces of disturbances and of metamorphism or change of nature by heat; and at such localities where no traces of thermal springs, or other phenomena of the same nature, indicate the influence of volcanic action.

When other substances, like clay, iron, sand, &c., have penetrated the trees or plants subjected to fossilization, the internal structure of the wood has been totally destroyed, and then nothing is left to indicate its primitive nature but a thin pellicle of charcoal surrounding the bark and preserving therefore only the outline of the outer surface of the trees. Trunks of this kind are often found either standing in their original form, or prostrated and flattened by compression in the sandstone of our coal measures. The peculiar conformations of the trees of this formation afford, from the scars of branches and leaves which have been left on the trunks, the means of comparing them and of classifying them, even according to their species. At some places, for example, near the Raccoon Furnace, in Northwest Kentucky, immense deposits of iron ore have been formed by the accumulation of stems and leaves of *Stigmaria* and *Cordaites*, which have been transformed into a rich carbonate of iron. The stems of *Stigmaria* have preserved their original form, not being flattened in the least, with the scars of their leaves perfectly distinct, as well as the medular canal and its star-like divisions.

When trunks are immersed for a great length of time in water which does not contain any kind of mineralizing element, the softer tissue becomes not only softened, but disaggregated in such a way that the woody matter is separated like a paste, excepting the bark, which longer resists this kind of disaggregation. In that way, and by compression, layers of bark of species of trees of the coal epoch are found in the shale, heaped upon one another in a more or less confused manner. The same phenomenon is observable, even at our time, in some peat formations of the North, for example in Denmark, near the border of the sea, in a large swamp out of which the peat is worked for combustible. This matter is a half fluid paste, a compound of débris of woody fibers. It is taken out in buckets, thrown upon beds of straw to drain off the water, and then compressed and dried, when it becomes a good combustible. In the meanwhile the bark of the trees from which this decomposed matter has been derived is taken out of the ditch, like rolled, hollow cylinders, and then dried separately and used as a combustible of less value.

It is especially from the petrification of leaves and small branches that our valuable and interesting specimens of fossil plants are obtained. Their fossilization is somewhat different from that of the trunks. Leaves falling in pools of quiet water, containing some muddy sediments, are softened, then compressed, and by the hardening of the imbedding matter the skeleton of their tissue is printed upon the stone, sometimes in its minutest details. In the shale of the coal-measures the matter of the leaves has been transformed into a thin pellicle of coal, which shows all the details of their structure. The exact outlines of whole fronds of ferns, their leaves in their minutest divisions, the stems, the pedicels, all the nerves and their branches, are there clearly printed in black upon the stone, offering in their details of structure, characters which serve to their determination. In some shale the leaves and branches are inclosed in concretions or nodules of carbonate of iron, wherein they have left the most beautiful and distinct impressions. Our tertiary and cretaceous measures contain leaves of trees which are preserved in the same way, in clay or soft sandstone, and which have left nothing on the shale but the print of the details of their structure, their outlines and their nervation, without any trace of their original substance.

The mode of preservation of the leaves varies like that of the trunks, according to the elements composing the matter in which they are imbedded, and especially according to the circumstances in which they have been deposited. Immense beds of coal, for example, have been formed from the remains of plants, while the coal itself scarcely shows any distinct prints, except sometimes upon thin lamellæ of dry charcoal which separate its layers. Per contra, the prints of fossil plants are abundantly seen in the shale which covers the coal. The reason of this difference is, that when the combustible is heaped by superposition of débris of wood, and no foreign element like clay or sand is mixed with it, the whole matter, by slow decomposition, is softened into paste, then compressed and hardened, forming a homogeneous mass. In this process all the tissues are destroyed or mixed, and therefore the original form of vegetables is rarely preserved. But when the growth of the peat or the heaping of the woody materials which have composed a bed of coal have ceased, and when by immersion the surface becomes covered by water, deep enough to stop the active vegetation which originated the coal, some hillocks or islands are left here and there above water, bearing the same kind of plants as those of the coal. Their branches in decaying fall into the water and are imbedded in its muddy deposits, which form the shale, and then preserved by fossilization.

It is in the same way that the leaves of trees, growing around the swamps at the time of our cretaceous or tertiary formations, have been deposited in clay, and preserved in a fossil state. Sometimes, however, leaves and woody débris have been transported and heaped at some places according to circumstances. In this case they are more or less damaged, rolled up, and mixed together in sandstone or clay, in a more or less indistinguishable mass. We have at our time examples of all these kinds of transportation, deposition, and preservation of leaves. We find them imbedded in the muddy deposits which cover our peat-bogs. The clay of our swamps is full of skeletons of leaves from the trees which surround them, and along our rivers, as, for example, of the Ohio River near Paducah, we find deposits of leaves floated down the river and buried in the bottom clay, in heaps of six to ten feet thick, where they still follow the same process of slow decomposition, whose ultimate term is complete petrification.

ON THE FOSSIL PLANTS CONSIDERED IN THEIR RELATION TO THE ACTUAL DOMAIN OF MAN.

As most of the strata composing the crust of the earth have been formed under water, and mostly contain remains of animals, especially of molusks, geology receives from animal paleontology far greater assistance for the determination of the strata and of their relative age than it can obtain from the study of botanical remains. Considered in this point of view, therefore, fossil plants appear of little importance. But when we come to demand from geology some instructions, some light concerning the surface of our earth at different epochs, science can answer nothing if it does not inquire into the data furnished by botanical paleontology. As vegetation is in absolute relation with atmospheric circumstances, the fossil plants are, indeed, the written records of the atmospheric and physical conditions of our earth at the epochs which they represent. In the Marcellus shale of the Middle Devonian, we see the first appearance of vegetation in the fossil remains of large trunks of coniferous trees found here and there imbedded in the shale, without any trace of branches or leaves. The shale also contains a quantity of fish remains and large flakes of black, coaly matter, apparently due to the decomposition of marine plants. It is an extensive formation, sometimes a few hundred feet in thickness, impregnated with bitumen, presenting everywhere the same characters. No other trace of land plants is left but these large fossil trunks. Where was the land then just emerging for the first time from its marine cradle? What was the aspect of the landscape? A black muddy surface covered with an atmosphere darkened by vapors, where nothing is distinguishable, but perhaps at wide intervals, a group of some trees emerging from the muddy bottom and breaking the universal gloom. No trace of animal life appears above the waters. All is dismal and silent.

In the Upper Devonian, the Chemung, the Catskill group, and especially the red shale of the subcarboniferous measures, largely developed in the anthracite basin of the Appalachian coal-fields, the remains of land plants are more frequently found. These are not trunks of fossil wood, but rather leaves and branches of a peculiar type of plants, ferns with flabellate leaves, especially *Noeggerathia*, which we do not find in the coal measures; and a few stems of *Lycopodiaceæ* and *Equisetaceæ*, the first representatives of a class of plants which constitutes the largest part of the vegetation of the coal. Leaves and branches of the Upper Devonian and subcarboniferous measures are compressed between layers of shales, which bear ripple-marks, fissures caused by heat, and round prints, evidently formed by drops of rain. If this does not indicate a succession of seasons of different temperature, it shows at least a distinct atmosphere, already penetrated by light, where changes of temperature cause condensation or diffusion—rain, followed, perhaps, by some rays of sunshine. Animal life also appears at the surface; crustaceans and large creeping saurians slowly plow their paths in the mud. Their traces have been preserved upon the shales; they indicate the first attempt at an ærial respiration.

In the coal formations the aspect of the landscape is totally changed. Everywhere the vegetable life predominates and attains its widest proportions; all still more or less under the influence of water. The emerged land is marked by a succession of immense low swamps, whose surface is concealed under a thick carpet of creeping plants, which fill them with their débris. Where the land has already some fixity, immense forests of large trees, mostly of the acrogenous kind, grow in a dense mass, of a size and height which compare with the largest trees of our time. They cover the land with a world of vegetation, which is scarcely now conceivable, even by the wildest imagination. All the vegetation is by its nature, its form, its texture, especially adapted to the absorption of atmospheric humidity and of carbonic acid. It is there at work cleaning the atmosphere, in transforming into woody fiber its surplus of water and of carbonic acid, and preparing it for animal life. For already, remains of saurians, scorpions, insects of large size, found in the shale of the coal, indicate that animal life has taken a marked place on the surface of the land. There is there also an evident distinction of seasons; the layers of coal show annual decay and periodical deposition of woody remains.

The lower permian has still for its land vegetation many species of plants of the coal-measures, but here the conifer appears, represented for the first time by their leaves and branches, and are of a peculiar order. The carboniferous vegetation loses its force by the disappearance of its arborescent acrogenous plants. The débris are no more heaped in immense deposits, but scattered here and there in the shales, or forming by their agglomeration mere flakes of coal. This indicates an atmosphere already discharged of greatest part of its carbonic acid and of vapors. The triassic, which, with us at least, touches, by the character of its flora, to the Jurassic, has plants which, like *Cycadeæ*, rather indicate a warm than a vaporous atmosphere. But for this and the following formations, the Jurassic, the data furnished by fossil plants on this continent are too scant to permit reliable conclusions. We have to pass to the lower cretaceous to find abundant remains of land plants, and here at once we have a vegetation absolutely different in its characters from all that has been seen before. All the forms (the needle form of leaves) which indicate atmospheric humidity, have disappeared; scarcely any conifers remain, very few ferns, no trace of *Lycopodiaceæ*, but leaves of dicotyledonous plants, representing already most of the genera of trees found in our forests. The vegetation is therefore of a kind known to us. The atmospheric circumstances are then analogous to those of our time. We now follow through the cretaceous and tertiary formations merely modifications of species, disappearance of some forms, reappearance of others, about as we should have to do now in studying our flora in passing through a few degrees of latitude*.

THE FOSSIL PLANTS IN RELATION TO OUR PRESENT CIVILIZATION.

To say that fossil plants have a relation to our present civilization appears at first sight a paradoxical affirmation. But what is coal? A mere agglomeration of petrified débris of plants. And who at our time could refuse to admit the influence of coal upon our actual civilization? Coal is the great generator of heat, of steam, of force; a potent auxiliary to every kind of enginery. It helps to the construction of our railroads; it brings them to countries which, without it, would remain deserts; and transports everywhere, with lightning speed, not only the necessaries of life, but the products of industry essentially due to its active coöperation. Coal is now used everywhere, and is the friend of everybody. It has become an object, not of mere commodity, but of absolute necessity.

The formation of the coal is now pretty well understood among geologists. It results from active growth of woody plants, whose débris, falling every year, are preserved against decomposition by stagnant water, or great atmospheric humidity. It is the process which now still forms our deposit of peat. It demands for its favorable action a ground or basin, rendered impermeable by a substratum of clay, a peculiar kind of plants, constantly growing at the same place, and heaping their débris for a length of time. At our epoch the formation of peat

* In the geological report of Dr. F. V. Hayden on the explorations of the Yellowstone River, under the direction of Brigadier General W. F. Raynolds, published in 1869, Dr. Newberry has clearly exposed the character of the vegetation in relation to each geological epoch.

is essentially of two kinds. Either the vegetables which furnish the materials are aquatic, or semi-aerial plants, having their roots in water, and expanding their branches, leaves, &c., on the surface of the water, or above it. Their débris falls in water, and are heaped and preserved under it. In another way, and this is more generally the case, the plants of the peat bogs are of a peculiar texture. Hygrometrical, like sponges, they absorb humidity by their aerial tissues as much as by their roots, and thus protected themselves against decomposition from atmospheric action, they cover in their growth every kind of woody débris, even large trees, and afford to them the same protective influence. In that way the surface of peat-bogs of this kind grow constantly up. In that way also peat-bogs grow at our time upon the slopes of steep mountains, whenever atmospheric humidity is constant and abundant enough to furnish moisture for the life of those hygrometrical plants, which now are mere mosses. The peat-bogs of the coal did grow in the same way; the distinction in cannel coal, which has been formed under water, and bituminous coal, which by its layers indicates an upper aquatic growth, is well marked. But during the carboniferous epoch, the circumstances favorable to the growth of the peat were in their highest development. Low, wide basins of stagnant water, whose bottom was first coated by deposits of clay; an atmosphere constantly charged with vapors and a large proportion of carbonic acid, the food of plants, forming by its transformation the woody tissues; floating vegetables of immense size, first growing horizontally at the surface of the water, and filling the basin with their débris, then forming a support for a more aerial vegetation; fern-trees, lycopodes, horse-tails, all of enormous size, heaped in a continuous growth the woody tissues of their vegetable remains in a now inconceivable proportion. Our thickest beds of peat now measure scarcely twenty feet. By compression and mineralization the thickness would be reduced to one-sixth, or three feet at the most. We have beds of coal of twenty feet of thickness which would make a deposit of peat reach one hundred and twenty feet. And now the result of this wonderful accumulation of fossilized débris of plants of the carboniferous epoch is known to everybody. We will not repeat what Taylor, Rogers, Lesley, Sheaffer, and others have published on the extent of our coal-measures and on their coal-bearing capacity. The area covered by the carboniferous formations in the United States comprises about one hundred and forty thousand square miles. It is true, indeed, that the peat bogs of old did not extend over the whole surface; that they were of various dimensions, separated by sandy hills or by deep lagoons; that after the deposit of their materials, erosions caused by water or other agency have greatly diminished their size. But it is true also that beds of coal, like the Pittsburg bed, whose average thickness is about eight feet, may be traced over surfaces more than one hundred square miles in width. It is equally true that beds of coal are superposed at intervals, in the coal measures, in such a way that at the same place a boring of a few hundred feet may successively pass through five beds of coal or even more of various thicknesses. A boring of seven hundred and fifty feet, recently made in the anthracite coal basin of Pennsylvania, passed through five beds of coal, respectively, four, eleven, five, twenty-eight, and five feet thick, or more than fifty feet of anthracite, with intervals of rocks, respectively two hundred and sixty, ninety-eight, one hundred and seventy-four, and one hundred and thirty-six feet. A section at Wilkesbarre, Pennsylvania, indicates sixty-two feet of coal in a thickness of about six hundred feet of measures. A low bed of coal, the equivalent of the mammoth vein of Pennsylvania, which averages eight to ten feet in thickness, is found over the whole extent of the coal measures of Ohio, Kentucky, Indiana, and Illinois, measuring from four to eight feet. So immense, indeed, are the riches of the American coal-measures, that in their conception of the future development of our human race, geographers, historians, philosophers, agree in this idea: that in the United States we have, especially in our coal deposits, the elements for the greatest and most perfect development of the human race.

And what is petroleum or mineral oil, too, which is now entering in our civilization, if not as one of its essential elements, at least as one of its potent auxiliaries? It is, like coal, the result of slow maceration of plants; with this difference, that in the formation of the coal, the plants which entered into the composition of the matter were woody or fibrous, and the woody tissue cannot be destroyed by the slow process of combustion no more than it is in burnt charcoal. The plants which concurred to the formation of petroleum were sea-weeds or marine plants. These have no fibers, no wood in their tissue, which is merely cellular; and in their decomposition all trace of this tissue has been destroyed, and pure bitumen preserved, either by impregnation of shale or sandstone, &c., or by accumulation in subterranean cavities. It is to fossil plants also that we owe the explanation of this remarkable process of mineralization. Deposits of oil are especially found in strata of the Upper Silurian and the Lower Devonian, and always in connection with shale or limestone, which contain in great quantity petrified remains of fucoids or marine plants. The conditions bringing up an exuberance of vegetation were already at work before the carboniferous epoch; their action resulted in the production of an immense marine vegetation. As nature does nothing in vain, as she takes care of all its materials and uses them, to the minutest débris, she took the bitumen away and preserved it in cavernous recesses for future use. By the discovery of our deposits of petroleum we have learned what had been done with the superabundant production of marine plants in our old geological epochs. Coal and petroleum are found in all the geological formations. But since the coal era the deposits of these matters have become of comparatively rare occurrence, and of far less importance, their value being diminished as much by the reduction of their areas as by the inferior quality of their products. They now take a nominal and far more modest place in the harmony of our earth's surface.

ON THE DISCORDANCE IN THE CHARACTERS OF EUROPEAN AND AMERICAN FLORA AT THE TERTIARY AND CRETACEOUS EPOCHS.

Since the first appearance of land vegetation upon the surface of our earth, what we know of it by fossil remains seems to indicate for our country a precedence in time in the development of botanical types. Large trunks of coniferous wood are already found in our Devonian measures, while analogous species are recorded as yet only in the carboniferous measures of England. Though the analogy of vegetation between the flora of the coal measures of America and Europe is evidently established by a number of identical genera and species, we have nevertheless some types, like the *Paleoxiris*, which are considered as characteristic of strata of the European permian, and which are found in our coal-measures as far down as the first coal above the millstone grit. Even peculiar ferns of our upper coal strata have a typical analogy with species of the oölite of England. Our trias, by the presence of numerous cycadeæ, touches the Jurassic of Europe. But it is especially from our flora of the lower cretaceous that we have a vegetable exposition peculiarly at variance with that of Europe at the same epoch, and whose types so much resemble those of the European tertiary that the evidence of the age of the formation, where the plants have been found, could not be admitted by paleontologists until after irrefutable proofs of it had been obtained.

Professor Newberry, in the report mentioned above, has already given sufficient details of the history of these plants, the scientific value of their discovery, the interest and the discussion which they have kindled. He has also rendered full justice to the researches of Dr. F. V. Hayden, to whom we owe what we may consider as the most important materials furnished at our time to the consideration of vegetable paleontology. Professor Newberry's enumeration of our cretaceous and tertiary plants is limited to what was known after the exploration of Messrs. Marcou and Cappellini in 1863. Since then the researches of Professor Hayden and Dr. J. Leconte have procured new materials, which have been described and figured for a final report of Professor Hayden's exploration. These materials are now briefly examined in order to render as complete as possible our review of the American cretaceous and tertiary flora and of its relation to the European flora of the same epochs.

SECTION 1.—CRETACEOUS FLORA.

In 1867 Dr. John Leconte had the kindness to send me a small lot of cretaceous fossil plants from Fort Ellsworth, Kansas; the same locality where had been obtained the cretaceous leaves collected by Messrs. Marcou and Capellini, and described by Professor Heer. These plants were figured and described as an appendix to a paper on species of fossil plants from the tertiary of the State of Mississippi.* Though the lot of these specimens was small, it furnished an interesting contribution to the fossil botany of the cretaceous, especially in confirmation of what had been already remarked on the miocenic facies of this flora. Besides *Proteoides acuta*, *P. grevilliæformis*, *Andromeda Parlatorii*, and *Magnolia alternans*, already described by Professor Heer in his memoir on the leaves of Marcou and Capellini, the appendix mentions a new species, *Populites microphyllus*, represented only by two partly-broken specimens; *Phyllites betulæfolius*, a leaf still smaller than the former ones, with irregularly dentate borders and an irregular (somewhat obscure) nervation; *Sassafras Leconteanum*, a fine large ovate lanceolate leaf, resembling, by its outlines, a leaf of Magnolia, but with the peculiar nervation of sassafras; *Persea Nebrascensis*, related to *Persea lancifolia* (Heer) and other species of the miocene and of the eocene of Europe; *Cinnamomum Heerii*, (Lesqx.,) a plant already described from specimens collected by Dr. J. Evans at Nanaimo.† This species, in both collections, is represented by one specimen only; and as the Ellsworth specimen has its base scraped away, and that of Nebraska has the point broken, the comparison of both leaves is not quite satisfactory, and therefore the identity is not certain. The leaves have, indeed, the same general out-

* Trans. Amer. Phil. Soc., Vol. XIII, page 340, Plate 23, May, 1867.
† Amer. Jour. of Nat. Science and Arts, Vol. XXVII, page 161.

line and the same kind of nervation, and if not of the same species, they belong to two nearly related species of *Cinnamomum*.

The following list is an enumeration of these cretaceous plants and of those sent me somewhat later by Dr. F. V. Hayden, Dr. Leconte, and a small lot presented to the Smithsonian Institution by Professor B. F. Mudge, of Kansas University. With the list of those published by Professor Heer and Dr. Newberry, which is given in Dr. Hayden's former report, the table completes the exposition of what is known till now of our cretaceous flora:

1. *Populus microphyllus*, Lesqx., Fort Ellsworth, J. L. C.
2. *Phyllites rutæfolius*, Lesqx., Fort Ellsworth, J. L. C.
3. *Persea Nebrascensis*, Lesqx., Fort Ellsworth, J. L. C.
4. *Sassafras Leconteanum*, Lesqx., Fort Ellsworth, J. L. C.
5. *Cinnamomum Heerii*, Lesqx., Fort Ellsworth, J. L. C.*
6. *Lygodium, (?)* fragment of fern, Northwest Salina, Kansas, B. F. M.
7. *Pterophyllum Haydenii*, Lesqx., Decatur, Nebraska, F. V. H.
8. *Glyptostrobus gracillimus*, Lesqx., Dakota County, Nebraska, F. V. H.
9. *Sequoia (?) formosa*, Lesqx., Decatur, Nebraska, F. V. H.
10. *Phyllocladus subintegrifolius*, Lesqx., Decatur, Nebraska, F. V. H.
11. *Arundo cretaceus*, Lesqx., Fort Ellsworth, L. C.
12. *Liquidambar integrifolius*, Lesqx., Northwest Salina, Kansas, B. F. M.
13. *Populus Lancastriensis*, Lesqx., Decatur, Nebraska, F. V. H.
14. *Populites cyclophylla, (?)* Heer, Decatur, Nebraska, F. V. H.
15. *Populites elegans*, Lesqx., Decatur, Nebraska, F. V. H.
16. *Populites ovata*, Lesqx., Dakota County, Nebraska, F. V. H.
17. *Populites quadrangularis*, Lesqx., Decatur County, Nebraska, F. V. H.
18. *Populites flabellata*, Lesqx., Lancaster County, Nebraska, F. V. H.
19. *Populites salisburiæfolia*, Lesqx., Lancaster County, Nebraska. F. V. H.
20. *Salix proteæfolia*, Lesqx., Decatur, Nebraska, F. V. H.
21. *Betula Beatriciana*, Lesqx., Beatrice, Gage County, Nebraska, F. V. H.
22. *Fagus polycladus*, Lesqx., Decatur, Nebraska, F. V. H.
23. *Quercus primordialis*, Lesqx., Decatur, Nebraska, F. V. H.
24. *Quercus hexagona*, Lesqx., Cass County, Platte River, Nebraska, F. V. H.
25. *Quercus Ellsworthianus*, Lesqx., Lancaster County, Nebraska, F. V. H.
26. *Quercus anceps*, Lesqx., Dakota County, Nebraska, F. V. H.
27. *Quercus semi-alatus*, Lesqx., Beatrice, Gage County, Nebraska, F. V. H.
28. *Ficus (?) rhomboideus*, Lesqx., Decatur, Nebraska, F. V. H.
29. *Ficus (?) fimbriatus*, Lesqx., Decatur, Nebraska, F. V. H.
30. *Platanus aceroides, (?)* Göpp., var. latior, Decatur and Lancaster, Nebraska, F. V. H.
31. *Platanus obtusiloba*, Lesqx., Beatrice, Gage County, Nebraska, F. V. H.
32. *Platanus diminutivus*, Lesqx., Beatrice, Gage County, Nebraska, F. V. H.
33. *Credneria Leconteana*, Lesqx., Fort Ellsworth, J. L. C.
34. *Laurus macrocarpus*, Lesqx., Decatur, Nebraska, F. V. H.

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* These five species from Trans. Amer. Phil. Society, loc. cit.; the following from Amer. Jour. of Science and Arts, Vol. XLV, page 91.

35. *Sassafras Mudgii*, Lesqx., Northwest Salinas, Kansas, B. F. M.
36. *Sassafras subintegrifolius*, Lesqx., Northwest Salinas, Kansas, B. F. M.
37. *Lyriodendron intermedium*, Lesqx., Decatur, Nebraska, F. V. H.
38. *Lyriodendron giganteum*, Lesqx., five miles north of Fort Ellsworth, Kansas, B. F. M.
39. *Magnolia tenuifolia*, Lesqx., Decatur, Nebraska, F. V. H.
40. *Dombeyopsis obtusiloba*, Lesqx., five miles north of Fort Ellsworth, Kansas, B. F. M.
41. *Acer obtusilobum, (?)* Ung., Decatur, Nebraska, F. V. H.
42. *Accrites menispermifolius*, Lesqx., Decatur, Nebraska, F. V. H.
43. *Negundoides acutifolia*, Lesqx., Salt Creek, Dakota County, Nebraska, F. V. H.
44. *Paliurus membranaceus*, Lesqx., Decatur, Nebraska, F. V. H.
45. *Rhamnus tenax*, Lesqx., Decatur, Nebraska, F. V. H.
46. *Phyllites rhoifolius*, Lesqx., Lancaster County, Nebraska, F. V. H.
47. *Prunus cretaceus*, Lesqx., Decatur, Nebraska, F. V. H.
48. *Phyllites umbonatus*, Lesqx., Beatrice, Gage County, Nebraska, F. V. H.
49. *Phyllites amorphus*, Lesqx., Decatur, Nebraska, F. V. H.

Besides these fifty species, or rather forms of fossil plants which are new for the American cretaceous, the specimens sent for examination have numerous representatives of the following species already decribed: *PlatanusNewberrii* Herr; *Laurus (Persea) Nebrascensis*, Lesqx.; *Sassafras cretaceus*, Newb'y; *Proteoides Daphnogenoides*, Heer; *Pr. acuta*, Heer; *Juglans (Populus) Debeyana*, Heer; *Prunus (Andromeda?) Parlatorii*, Heer; and *Phyllites Vannonæ*, Heer. There is especially a great quantity of specimens of that peculiar *Juglans Debeyana* whose leaves, some of them at least, resemble leaves of *Populus*. The great difference in their size, and in the length of the pedicels; the mode of curving to one side, or dissymmetry of the small ones, while the largest are exactly symmetrical, mark them as separate leaflets of a compound leaf. For this and their nervation, they are referable to *Juglans*. Both species of *Proteoides* are also represented by a large number of specimens, all with the former obtained from the same locality.

Considered in its whole, this group of plants has a strong miocenic facies; though we find in it already two species belonging to genera characterizing the European cretaceous. One is *Pterophyllum Haydenii*, a plant whose generic name cannot be correct or does not indicate the true botanical relation; for neither its leaves nor its cone can be referred to *Cycadeæ*. But two fragments like ours, of branch with leaves and of a cone, have been described and figured under this generic name by Stiehler, from the cretaceous of Europe, and the affinity of this plant being unknown, I preserved the name on account of geological analogy. The other species is the beautiful *Credneria Leconteana*, a large leaf, represented by a single specimen, unluckily broken. The essential character of the genus is preserved in a small part of the basilar horizontal nerve, as seen in the figure. A few of these new species of our cretaceous do not have any analogy with any others known as yet from the tertiary or the cretaceous or from the flora of our time; the species, for example, described under the generic name of *Populites*, which have the secondary nervation straight and continuous to the borders, like leaves of *Platanus*, the round outlines of leaves of *Populus* with their base narrowing to a long, slender petiole as in the Beech; the leaves also described as *Quercus semi-alatus*, which are broadly lobed on one more enlarged side, and entire ovate on the other. Especially of unknown type is the peculiar *Ficus (?) fimbriatus*, represented by a broad, reniform leaf, whose borders are fringed by small, nearly triangular, concave protuberances, equally distant from each other, and turned upwards.

Out of those few exceptions, the primordial character of the flora, as indicated by the plants enumerated above, is distinctly Northwest American. The list contains species of *Liquidambar*, *Populus*. *Salix*, *Betula*, *Fagus*, *Quercus*, *Platanus*, *Sassafras*, *Liriodendron*, *Magnolia*, *Acer*, *Rhamnus*, *Prunus*, &c. If some of these species may be regarded as of uncertain value, there can be no doubt on their relation to the genera to which they are assigned, all represented in our actual flora. Even the exceptions to this Northwest American character are very few. Besides the now extinct races, like *Credneria* and *Dombeiopsis*, we can record only the species of *Proteoides* as referable to Australian forms, with *Phyllocladus*, indicating an Eastern Asiatic origin. This last is represented by a single specimen, which, though well preserved, is not sufficient to prove generic affinity. As for the genus *Cinnamomum*, it is so closely related to *Sassafras* that its nativity could as well be assigned to this country, if it did not have more numerous representatives in the tertiary and cretaceous formations of our western continent, thus indicating its origin from Asia, where a number of its species have been preserved to our time.

From all that has been published on the subject, it is fully established that besides its Asiatic types, the original characters of the miocenic flora of Europe are Northwest American. It is not therefore surprising that the first fossil plants of our cretaceous measures should have been considered as miocenic as long as their geological position had not been positively ascertained. But even now, with full evidence afforded to us on the subject, it may be still doubted if the relation of epochs between the plant-bearing strata of Nebraska and those which lay over them and contain cretaceous mollusks is rightly indicated by the fossil remains. For as it is now ascertained that at a great depth the present fauna of our seas is related, if not analogous, to the fossil fauna of some cretaceous rocks, the depth at which have been deposited the calcareous strata overlaying the sandstone containing our leaves, may have caused what might be called an unconformable development of zoölogical types. This question is merely hypothetically touched in order to present it to the attention of geologists and paleontologists.

SECTION 2.—TERTIARY FOSSIL PLANTS.

We have first to complete the list of our tertiary fossil plants as it has been done for those of the cretaceous formations. Besides the species described from the specimens of Dr. F. V. Hayden and Dr. Leconte, the following list enumerates a number of others from the tertiary of Mississippi. These have been established from specimens furnished by Professor E. W. Hilgard, mentioned in his geological report of the State of Mississippi,* and hereafter described and figured in Trans. Am. Phil. Soc., as remarked above. Their geological position is not definitively ascertained. They appear referable to the lower tertiary, (the eocene.)

Species from Mississippi:

Calamopsis Danai, Lesqx.
Sabal Grayana, Lesqx.
Salisburia binervata, Lesqx.

* Report on the Geology and Agriculture of the State of Mississippi, by Eug. W. Hilgard, (1860,) pp. 108, 109, &c.

Populus monodon, Lesqx.
Populus mutabilis var. repando-crenata, Heer.
Salix Worthenii, Lesqx.
Salix tabellaris, Lesqx.
Quercus Moorii, Lesqx.
Quercus Lyellii, Heer.
Quercus retracta, Lesqx.
Quercus chlorophylla, Ung.
Celtis brevifolia, Lesqx.
Ficus Schimperi, Lesqx.
Ficus cinnamomoides, Lesqx.
Laurus pedatus, Lesqx.
Cinnamomum Mississippiense, Lesqx.
Banksia Helvetica, Heer.
Persea lancifolia, Lesqx.
Ceanothus Meigsii, Lesqx.
Sapindus undulatus, Al. Br.
Rhamnus marginatus, Lesqx.
Juglans appressa, Lesqx.
Juglans Saffordiana, Lesqx.
Magnolia Hilgardiana, Lesqx.
Magnolia laurifolia, Lesqx.
Magnolia Lesleyana, Lesqx.
Magnolia oralis, Lesqx.
Magnolia cordifolia, Lesqx.
Asimina leiocarpa, Lesqx.
Ph yllites truncatus, Lesqx.

Species collected by Dr. J. Leconte:*

Rhamnus obovatus, Lesqx., upper end of Purgatory Cañon, Colorado.
Arundo, fragments, Purgatory Cañon, Colorado.
Berchemia parvifolia, Lesqx., Raton Pass, Colorado.
Cinnamomum affine, Lesqx., Raton Pass, Colorado.
Abietites dubius, Lesqx., Raton Pass, Colorado.
Juglans Leconteana, Lesqx., Raton Pass, Colorado.
Echitonium Sophiæ, (?) Web., Raton Pass, Colorado.
Acer, (?) numerous small fragments undeterminable.

Species from Dr. Hayden's specimens:

Cornus incompletus, Lesqx., Marshall Coal, Colorado.
Rhamnus salicifolius, Lesqx., Marshall Coal, Colorado.
Cinnamomum affine, Lesqx., Marshall Coal, Colorado.
Lygodium, fragment, Marshall Coal, Colorado.
Phyllites sulcatus, Lesqx., Marshall Coal, Colorado.
Echitonium Sophiæ, (?) Web., Marshall Coal, Colorado.
Juglans Leconteana, (?) Lesqx., Marshall Coal, Colorado.
Quercus Lyellii, (?) Heer, Marshall Coal, Colorado.
Quercus chlorophylla, (?) Heer, Marshall Coal, Colorado.

Dr. Leconte obtained from the same locality fragments of *Acer* allied to *A. strictum*, Göpp.; of *Juglans* allied to *J. acuminata*, Heer; of *Cornus*, *Banksia*, &c.; all too small and broken for satisfactory examination.

* These species and the following ones of Dr. F. V. Hayden have been figured and described for the final report of Dr. Hayden, but the descriptions have not been published as yet.

With these, in specimens of Dr. Hayden and Dr. Leconte:

Lastræa (?) *dentata*, Lesqx., Golden City, Colorado.
Magnolia tenuinervis, Lesqx., Golden City, Colorado.

And from Dr. Hayden's specimens:

Platanus aceroides, Heer, Rock Creek, Wyoming.
Populus attenuata, Al. Br., Rock Creek, Wyoming.
Populus subrotundus, Lesqx., Rock Creek, Wyoming.
Populus æqualis, Lesqx., Rock Creek, Wyoming.
Quercus acrodon, Lesqx., Rock Creek, Wyoming.
Quercus Haydenii, Lesqx., Rock Creek, Wyoming.
And fragments of *Acer* and *Populus*, species undeterminable.

The group of plants from Mississippi has a more recent facies than the cretaceous leaves of Nebraska. Except the beautiful pinnate palm, (*Calamopsis*,) distantly related to species now living in equatorial regions, and a remarkable *Salisburia*, which does not in the least resemble the only remaining species now living in China, most of its genera are represented here at our time, and a number of its species are allied to living ones. Some others, like *Quercus Lyellii*, *Q. chlorophylla*, *Banksia Helvetica*, *Sapindus undulatus*, are considered as identical with species of the miocene of Europe, and this all, therefore, indicates with the miocenic age a nearer relation than that marked by the characters of the cretaceous flora of Nebraska and Kansas. This, however, is not a positive evidence of contemporaneity, and it is probably right that the strata where these fossil plants were obtained should be considered as pertaining to the eocene, or even to the upper cretaceous. Indeed, Dr. Leconte's species from Raton Pass are not less miocenic in aspect, for, except the numerous fragments of an *Abietites*, analogous to remains of the same kind from the European cretaceous, all the genera are represented at our time. From the animal remains, however, found in connection with the coal-bearing strata of Raton Pass, Dr. Leconte considered them as cretaceous.* If it is right, from what we have seen of its fossil flora, the Marshall's Coal should be admitted also as of cretaceous age, as the specimens from both localities have plants apparently identical—*Cinnamomum affine*, *Echitonium Sophiæ*, *Juglans Leconteana*. These specimens are indeed very incomplete—mere fragments representing vegetables whose identification is difficult and not absolutely reliable; nevertheless, the flora bears, evidently, the same character at both localities, as its facies also is related to that of the Mississippi flora. The character is far different from that of our true miocenic flora, as it is indicated by the small group of plants obtained by Dr. Hayden at Rock Creek, Nebraska; for here on six species only there are two identical with miocenic species of Europe, and five are closely allied to species of our Eastern North American forests. One only, the beautiful *Quercus Haydenii*, is related to species of our Western coast. The specimens of Rock Creek are mostly perfect remains of plants easily studied, and their characters undoubtedly ascertained.

No less miocenic in their characters, though of different family relations, are the remains of fossil plants obtained by Dr. F. V. Hayden in his last exploration, and just now received for examination. These specimens merely belong to two strata; those labelled Henry's Fork, Muddy Creek, and Black Fork being on a kind of hard, silicified limestone, with remains of the same species of plants, and therefore indi-

* Notes on the Geology, &c., from Smoky-Hill River, Kansas, to the Rio Grande, by J. L. Leconte, 1868. Columbus, 7th January, 1871.

cating identity of horizontal station; those from Barrel's Spring upon yellow ferruginous shale, having upon all the specimens the same species of fossil plant also, but of a different group from that of the former.

Henry's Fork specimens have:

1. *Pteris pennæformis*, Heer, in numerous but indistinct specimens. The species may differ somewhat from that of Europe, but, in the state of the specimens, the difference is not appreciable. It is a large, lanceolate leaf, varying from one to three inches in length, and from one-half to three-fourths of an inch broad, with a thick, half-round medial nerve, and thick, mostly simple, secondary veins, obliquely curving to the borders. This species is not rare in the miocene of Germany and Switzerland.

2. Broken, obscure remains of a large leaf, with thick, oblique, straight, closely approached secondary veins; neither the middle part nor the medial nerve, nor the borders are seen. It may be compared only to some *Palmacites*, or to the leaf described as *Zingiberites*, from the miocene of Europe, by Professor Heer.

3. Fragments of a *Calamopsis*, or palm leaves, (rachis not seen,) one inch broad and as far distant from each other, marked lengthwise with four narrow tertiary veins between the more distinct secondary ones, five to six in number.

4. Leaves of a *Cyperites*, with the same areolations as *Cyperus Chavanensis*, Heer, but only half as broad.

From Muddy Creek:

5. *Aspidium (Lastraea) pulchellum*, Heer, or *A. Fisheri*, Heer. Though small, the specimens are distinct. The leaflets are slightly broader than in this last species, and not quite as large as in the former. An intermediate form, equally referable to both of the species of the miocene of Europe. All the specimens of the former and of the following locality have fragments of it.

From Black's Fork: The specimens have only fragments of the last species, and of *Pteris pennæformis*, with undeterminable leaves of *Cyperites*, resembling *Carex tertiaria*, Heer.

Barrel Spring: All the shale have numerous remains of the three following species. The fourth is represented in only one:

6. *Lygodium neuropteroides*, Spec. nova. A beautiful fern, of which only separate leaflets are preserved. These, from one to two and a half inches in length, proportionally broad, are linear lanceolate, slightly obtuse, either entire or more generally divided from below the middle in two or three linear lanceolate lobes, like the living *Lygodium Salicifolium*. But the nervation is far different, rather comparable to that of a *Pteris* than to that of a *Lygodium*. The medial nerve is thin; the secondary nerves branch three or four times in curving to the borders. It is a nervation like that of some species of *Neuropteris* of the coal measures, especially of *Neuropteris hirsuta*, which the large, entire leaflets also resemble in their form. The relation of this beautiful fern is with species of *Lygodium* and of *Osmunda* of the European miocene, but this relation is distant indeed.

7. A floating stem, like *Myriophyllum*, referable perhaps to one species of this genus. As the divisions are pretty thick, it may be rather compared to the roots and rootlets of *Pragmites Oenigensis*, Heer. It is evidently related to species of our time. This *Pragmites* of Heer is from the miocene of Europe. Leaves of a species of this genus have been published by the same author from the tertiary of Alaska.

Cyperus Deucalionis, Heer. The specimens have a number of leaves of this species, which show all the varieties of the European plant without any appreciable difference, varying from one-eighth to one-fourth of an inch broad. The broadest of ours is just of the same size as the leaf published in Sismonda's memoir, from the tertiary of Italy, as *Cyperites Deucalionis* ? Heer. It is evidently the same species.

9. Fragments of leaves of a *Sabal*. The rachis is not seen, and therefore the species is not determinable. By the large divisions of its leaves, it resembles *Sabal major* of common occurrence in the miocene.

10. A sheath-bearing leaf of grass, undistinguishable from the one figured by Heer in his tertiary flora, Tab. XXV, Fig. 10, and described as *Poacites lævis*.

From the small number of the above-mentioned species, it is not possible to mark between both groups of plants a difference of stage in the formations where they have been found. But it is evident that none of these species indicates an older formation than that of the middle tertiary or miocene. All the Glumaceæ, species of *Carex*, *Cyperus*, *Arundo &c.*, have not been found as yet in formations older than the tertiary, and our ferns of the group of *Aspidium* (*Lastræa*) as well as all the species of *Lygodium*, are also characteristic of the miocene formation. Therefore the group of these plants, taken in its whole, is evidently of the middle tertiary.

The peculiar facies of these plants indicates their origin as from prairie swamps, covered merely with grasses, ferns, and low palms. The fossil remains do not show any traces of leaves of dicotyledonous trees, or of any arborescent plant whatever. It is for the first time that this facies, so often remarked in tertiary specimens of Europe, has been observed in those of our country.

COLUMBUS, OHIO, *January* 12, 1871.

VI.—ON THE FOSSIL REPTILES AND FISHES OF THE CRETACEOUS ROCKS OF KANSAS.

BY PROF. E. D. COPE.

REPTILIA.

The species of reptiles which have been found in the cretaceous strata west of the Mississippi River up to the present time number fourteen. Five of these pertain to the *Sauropterygia*, one to the *Dinosauria*, and seven to the *Pythonomorpha*. In the present report attention is confined to the species discovered near the line of exploration of Dr. Hayden, or that of the Kansas Pacific Railroad, and that of Professor B. F. Mudge, of the State Agricultural College.

During the period when the cretaceous ocean extended from Eastern Kansas over the present site of the Rocky Mountains, and from the Gulf of Mexico to the Arctic Sea, it abounded in life. Among vertebrata, fishes and marine reptiles chiefly abounded, and in varied forms. Many of the reptiles were characterized by a size and strength exceeding that seen in any other period of the world's history. The species of *Sauropterygia* and *Pythonomorpha* were all aquatic, but the two types present very different adaptations to their mode of life. While the former possessed two pairs of limbs, the latter appear to have possessed an anterior pair only, or with the posterior pair so reduced as to have been insignificant. They substituted for them an immensely long and flattened tail, which they used, like the eels and sea-snakes, as an oar. The *Sauropterygia* were generally stout-bodied and with a very markedly distinct neck. In the *Pythonomorpha*, on the other hand, the body was snake-like, with narrow chest and neck scarcely differing in diameter. They were immensely elongate, and might be called sea-serpents with considerable propriety.

Of *Sauropterygia*, *Polycotylus* had a slender neck and very stout limbs; but in *Elasmosaurus* the neck attained dimensions exceeding that of any vertebrated animal. The species *E. platyurus* was probably the longest of the order, measuring perhaps fifty feet, but of this the neck amounted to twenty-two feet. This creature was carnivorous, and could, no doubt, like the snake-bird, swim at a considerable distance below the surface of the water and reach to the surface for air, or explore the depths or plunge for fishes to the depth of forty feet.

Among the *Pythonomorpha* the *Liodon dyspelor* is the largest species and the *Clidastes intermedius* the smallest. A specimen of *Mosasaurus missuriensis* obtained by William Webb near Topeka is stated by him to measure seventy-five feet in length. Should this be substantiated, the *L. dyspelor* was at least one-third larger. This is, however, as yet uncertain.

The upper arm bones of the Clidastes are remarkably short and wide, and furnished with strong processes for the insertion of muscles. They are among reptiles much like those of moles among quadrupeds, and, as in the latter, indicate probably great power of propulsion in the fore limbs. The finger bones were long and slender and formed a long fin or flipper, while the upper arm was probably concealed in the skin. The whole limb came off but a short distance posterior to the head.

These reptiles, so far as known, were all carnivorous; their food was chiefly fishes. Some of the species on which they preyed are enumerated in the portion devoted to them, and their structural characters pointed out.

As it is desirable to develop the science of geology, the writer would be glad if his friends in the West would forward to him, in Philadelphia, at his expense, specimens of bones or teeth which they may find. He will return to them determinations of their nature, and credit them with discoveries which may result from their care and interest in preserving them, in the publications of scientific bodies.

SAUROPTERYGIA.

POLYCOTYLUS, (COPE.)

Trans. Amer. Philos. Soc., 1869, p. 34.

This genus is established on a series of vertebræ with portions of pelvic arch and posterior extremity, discovered in the upper cretaceous of Kansas by W. E. Webb, superintendent of the land office in Topeka, Kansas. The point at which the remains were found is about five miles west of Fort Wallace on the plains near the Smoky Hill River, Kansas, in a yellow cretaceous limestone.

The animal thus indicated is of interest in American vertebrate paleontology, as the first true *Plesiosauroid* determined within our limits. That its affinities are nearer to *Plesiosaurus* than to *Elasmosaurus* will be apparent from the following description.

There are wholes or portions of twenty-one vertebræ, of which but two retain their neural arches, and six are represented by neural arches only. Four centra may be referred to the caudal series, the remainder to the dorsal; only two indicate the characters of the cervical vertebræ. All of these vertebræ, except the distal caudals, are remarkable for their short anteroposterior diameter and deeply-concave, articular faces. This concavity is not, however, of an open conic form, as in *Ichthyosaurus*, but is flattened at the fundus, thus exhibiting a small, slightly disciform area. The usual pair of venous foramina appears on the under side of the centrum. The neural arch is continuous with the latter, and exhibits no trace of connecting suture. The diapophyses arise from the neural arch in all the dorsals; they are compressed and vertical in section. The arch is of course narrow anteroposteriorly, and presents a pair of moderately prominent zygapophyses in each direction, the posterior as usual articulating downwards, the anterior upwards. On some of the vertebræ they become closely approximated. The neural spines are narrow anteroposteriorly, but much stouter transversely than in *Elasmosaurus*; they are strongly grooved at the base, both anteriorly and posteriorly, most so posteriorly.

The caudal vertebræ are anteriorly quite as large as the dorsals. Two anterior caudals present, on the latero-inferior part of the posterior margin, a pair of widely-separated, articular surfaces for chevron bones. A portion of one of the latter remains; it is narrow and subcylindric at the base. The diapophyses are situated on the upper part of the centrum, and are continuous with it, and without trace of suture. There are two distal cervicals which are much smaller than the preceding. They are solidly coössified and have been broken from one anterior to them, with which they have been also ankylosed. Processes in the position of the diapophyses have disappeared, while a strong infero-lateral process projects from the middle of each, similar in position to the parapophyses (or whatever they may be) of the *Elasmosaurus*. These processes are decurved and much thickened and rugose; they may be described as more or less elongate conic. The neural canal of these vertebræ is well marked, though small. The coössification of cervical vertebræ is a remarkable character, and very unusual. It does not seem probable that these specimens represent a diseased condition, since they are symmetrical, and the inferior surface and foramina are unaffected. The rugosity is much that of a ligamentous articulation. Their size indicates a remarkably slender neck as in *Plesiosaurus*, but even more so, and perhaps as elongate as in *Elasmosaurus*.

That the portions of an extremity alluded to belong to the posterior is rendered probable by the presence of part of an ilium, and by the fact that the portions of the vertebral column secured are chiefly median and posterior. The fragments consist of the extremity of the femur, the tibia, several tarsal bones, and numerous phalanges. The whole limb is of great size, compared with the vertebral column, and indicates powerful natatory capacity in its possessor. What the relative length of the femur may be cannot be ascertained, as the proximal portion is wanting, but if it were like the tibia it was characterized by stoutness rather than by length. The portion remaining is flattened, and presents distally two distinct articular faces for ulna and radius, instead of the uniformly convex outline characteristic of most of the species of *Plesiosaurus*. The tibia is pentagonal, broader than long, and not emarginate externally. The fibula is wanting. One of the tarsal bones is a flat, unequally hexagonal disk, of less thickness than the tibia and the tarsals which appear to connect with it. One of the latter is transverse parallelogrammic, with three faces of broad plane articulations and the outer edge rounded in section. Another tarsal or metatarsal is a parallelopipedon except that one extremity presents two faces meeting at a right angle. Another is similar, but oblique, *i. e.*, rhombic in section ; one of the longitudinal angles is also prolonged.

Of the phalanges there are individuals from three series. Portions of flat bones, perhaps belonging to the pelvic arch, indicate, as do all the other pieces, that the bony structure in *Polycotylus* is more massive than in *Elasmosaurus*, if the only known species has not attained such huge dimensions as some of the latter. These fragments do not throw much light on the structure of the pelvic arch.

The structure of the bones is, like that in the order generally, of the coarsest description. There are no medullary cavities, but the medullary cells are large, and extended everywhere in the direction of the axis of each bone.

The characters which separate this genus from *Plesiosaurus* may be derived from the preceding as follows:

First. The deeply biconcave, and very short vertebral centra.

Second. The tibia broader than long, resembling those of *Ichthyosaurus*.

Third. The coalescence and depression of the cervicals.

Fourth. The continuity of the neural arches.

Fifth. The continuity of the diapophyses of the caudals.

The only genus with which this genus compares nearly is the *Thaumatosaurus* of Meyer. This is known by but a few fragments, and of these but few are present in the Kansas animal. The character on which I rely at present to distinguish them is the much less concavity of the dorsal vertebræ in *Thaumatosaurus*. This is, however, not entirely satisfactory. *Thaumatosaurus oolithicus*, Meyer, is from the lower oölite of South Germany.

The bones are thoroughly mineralized, and the adherent matrix is a light-yellow, chalky limestone, similar to that which yielded the fine fragments of the *Liodon proriger*. This, Dr. Leconte informs me, is probably Meek and Hayden's Upper Cretaceous No. 3, and is a higher horizon than that near Fort Wallace, from which Dr. Turner procured the *Elasmosaurus platyurus*. The specimens were all taken out under the direction of W. E. Webb, of Topeka, from the same spot. From every point of view there is reason to believe that they belong to the same animal.

POLYCOTYLUS LATIPINNIS, (COPE.)

Loc. Cit., p. 36, Plate I, Figs. 1–13.

The anterior dorsal vertebræ have the centra slightly compressed or vertically oval, while the posterior are more rounded. The anterior caudals appear to have been round or nearly so; they are somewhat distorted by pressure. The sides of the centrum are slightly concave in the longitudinal direction ; below there is no carina, but at least two venous foramina. There is another large foramen on the side of the centrum, usually not far from the neural arch ; there are usually other smaller foramina below this. The bases of the diapophyses are longitudinally grooved behind, and separate a concavity of the arch in front of them from one behind. In the most median the most elevated diapophysis stands about equally on the neurapophysis and the neural spine above it. The diapophyses are vertically compressed, and the costal articulation of the only one preserved is in the same plane. The margins of the external surfaces are not coarsely striate as in many *Sauropterygia*. The venous foramina of the distal cossified cervicals are in pairs, and of large size. In the proximal caudals the diapophyses are above the middle of the sides of the centra. In one the basis of a chevron is preserved. It is cylindric and striate. The zygapophysis on the hinder aspect of a dorsal has a disciform articular surface directed outwards and downwards; the prominence of its upper face is continuous with the lateral ridge of the neural spine. The anterior uplooking surface is equally small and little divergent.

	Inches.
Length two coössified cervicals	2.5
Width anterior in front	1.7
Depth anterior in front	.9
Vertical diameter centrum dorsal	3.42
Transverse diameter centrum dorsal	2.7
Antero-posterior diameter centrum dorsal, (below)	1.85
Vertical diameter centrum dorsal, (poster)	2.98
Transverse diameter centrum dorsal	2.9
Transverse diameter neural canal	.86
Longitudinal diameter base neural spine	1.22
Longitudinal diameter base diapophysis	1.2
Length between extremities zygapophyses, (dorsal)	2.26
Depth of cup of vertebræ	.63
Length centrum anterior caudal	1.73
Distance between bases chevron bone, (caudal)	2.58

It may be observed the anterior caudals have a nearly round articular extremity; one of them is a little wider than high, but they are too much distorted to furnish reliable measurements.

The portion of ilium preserved is an extremity. It is flat on one side and convex on the other. The shaft is solid. The articular extremity is oblique, and presents a truncate extremity, which is at right angles to a short, recurved margin, which has been an insertion or articulation; the flat surface is rugose distally. Long diameter of extremity, 2.75 inches; of shaft, 1.9 inches. The articular faces of the extremity of the femur are at an open angle with each other, and are strongly concave in transverse section. The femur is here very flat, with narrow margins; it becomes stouter with diminishing width. Distally the surface is marked by grooves and small foramina. What may be tibia is the basal frustum of a wedge; the articular faces broad, the outer margin narrowed; the faces slightly concave. The inner margin is shorter than the outer, and the distal part of it presents a broad, articular face. Some of the tarsal bones have been already described. There are thirteen metatarsals and phalanges. They are of stout proportions and are considerably constricted medially. Those of one series are square in section; those of another, transverse; those of the third transverse with one edge thinned or acuminate in section. Some of each form are more elongate than others.

	Inches.
Width femur at extremity, (restored)	8.
Depth femur at extremity, (median)	1.3
Width femur four inches from extremity	6.
Thickness femur four inches from extremity	1.95
Width tibia	3.88
Length externally	2.6
Width tarsi tibiale	2.48
Thickness tarsi tibiale	1.52
Length parallelopiped phalange	1.56

	Inches.
Width parallelopiped phalange	1.2
Thickness parallelopiped phalange	1.2
Thickness depressed phalange	1.
Width depressed phalange	1.4
Length depressed phalange	1.9

These powerful extremital pieces indicate a body to be propelled, of not less than usual proportions. If this be the case the number of dorsal vertebræ is considerably greater than in the species of this order in general, and approaching more the *Ichthyosauri*. I do not intend to suggest any affinity between the latter and the present genus, as none exists. What the extent of cervical vertebræ may have been is uncertain. The caudals have probably been numerous, though not probably so extended as in *Elasmosaurus*.

The size of the species can be approximately estimated from the proportions furnished by Owen (Reptiles of the Liassic Formations) for *Plesiosaurus rostratus*. The skeleton of this species measures eleven feet eight inches, and the dorsal vertebræ are of less vertical and equal transverse diameter compared with those of the present saurian. We may therefore suppose that the latter exceeded the former in dimensions.

William E. Webb, of Topeka, discovered the specimens from which this species was first described, and liberally forwarded them to me for examination and description. Other specimens have been discovered since that time by various other persons. I have received numerous fragments of an individual of about the size of the one above described, which were found by Professor B. F. Mudge, at a point near the mouth of the north branch of the Smoky Hill River.

These consist of a few vertebræ, portions of pelvic and scapular arches, and three proximal bones of the limbs. Which of these is femur and which humerus I am unable to determine, owing to their close resemblance. The vertebræ do not differ from those of the specimen just described. The limb bones are stout and expanded and thinned distally; this thinning is remarkable and indicates a much-flattened metapodial region. The head is slightly expanded, the articular face being turned obliquely to the inner face of the shaft; the surface is pitted for attachment of the articular cartilage; two-fifths the length from the proximal end is an extensive and exceedingly rugose surface, as wide as the shaft, for the insertion of the adductor muscles.

	M.
Diameter of centrum of lumbar vertebræ	0.08
Length (?) humerus	0.45
Diameter head	0.125
Diameter shaft	0.098
Diameter distal end (transverse) restored in part	0.18

Should the humerus have been related to the fore limb as in *Plesiosaurus dolichodirus*, Conyb., the latter would have had a length of four feet three inches; as the proportions of the radius and phalanges are shorter, the limb was probably relatively shorter. If related to the total length, as in the same *Plesiosaur*, the humerus would indicate a length of seventeen and a half feet. As the cervical vertebræ become attenuated as compared with the dorsals to a greater degree in *Polycotylus* than in *Plesiosaurus*, I have little doubt that the length of this species exceeded that amount.

ELASMOSAURUS, (COPE.)

Leconte's Notes on Geology of the Route of the Union Pacific Railroad, 1868, p. 68. Cope, Proceed. Acad. Nat. Sciences, 1868, p. 92. Transac. Amer. Philos. Soc., 1869, p. 44.

This genus has been more completely preserved to us than any other American representative of the order, and hence may be accepted as most clearly expressive of its characters. In the interpretation of these, however, considerable difficulty has been experienced, as the structure form appears, at first sight, to reverse, to a remarkable degree, the usual proportions of known reptiles.

The determination of the anterior extremity of the vertebral column has been rendered certain by the fortunate completeness of the cervical series, as the extraordinary length of the latter, equaling three times that of the body, renders the most careful scrutiny necessary.

The neural arches are every where continuous with the centra, without sign of suture, and are externally plane. The neural canal is exceedingly small for the size of the vertebræ, especially on the lumbars and caudals.

The dorsal vertebræ are remarkable from the fact that the diapophyses disappear on the anterior part of the series, and gradually diminish in length from behind forwards to the point of disappearance. On the median and posterior parts of the series, they are very elongate, and rise for a short distance from the basis of the neural arch. Anteriorly, they descend and shorten, and finally remain only as the slightly elevated borders of rib-pits. Throughout the whole of the anterior portion of the column to the cervicals, the neural spines are of great elevation, and of such antero-posterior extent as to be nearly continuous.

The cervical vertebræ are not only more numerous, but become anteriorly much smaller and more attenuated than in its allies of the same family. They are remarkably compressed, the centra much longer than deep, and deeper than wide, and with smooth concave sides.

The ribs of the anterior cervico-dorsal region are inserted directly in the vertically oval pits of the centrum. Immediately at the point where these cease thin transverse processes appear to arise from the lower edges of the rib pits. They form a continuous series with the ribs, and soon rise from the plane of the lower face of the centrum, and are directed obliquely downward. At the end of the cervical series they are directed nearly vertically downward. The number of these vertebræ is very great, the anterior diminishing to a very small size; the whole measuring a little more than half the total length.

Most of the cervicals possess two venous foramina below; the dorsals two, and most of the caudals one.

The resemblance of the caudals to the usual type of *Plesiosaurus* is seen in the fact that each bears near its posterior articular aspect, on the inferior face, a pair of articular surfaces for chevron bones. Similar vertebræ had been described by Leidy as the caudals of a genus he called *Discosaurus;* the study of the present genus shows that they are really of the caudals of the allied genus *Cimoliasaurus*.

The ribs are simple-headed; the abdominal ribs seen in *Plesiosaurus* are possibly wanting, as none are found by the discoverer of the fossil, after a careful search.

The end of the muzzle, with symphysis mandibuli, was preserved. This is flat, the symphysis rather short, the premaxillary grooved at the intervals between the dental alveoli. The teeth are deeply implanted, with small pulp cavity; are cylindric, and furnished with nearly straight elongate conic crowns, which are minutely but sharply striate to the tip; the ridges straight, continuous. There are no indications of nostrils, so that these were probably posterior, and near the orbits, as in *Plesiosaurus.*

The pelvic arch is more extended than the scapular, and strongly resembles the pelvic arch of other *Plesiosauridæ.* The scapular arch is peculiar; the claviculi are broad, flat bones, resembling the pubes of certain tortoises, while the coracoids are much like the coracoids of *Plesiosaurus.*

The scapular arch is remarkable for the resemblance of coracoids to those of *Plesiosaurus.* The clavicles have a greater transverse extent than the former, and have a very extensive line of union medially, and a narrow posterior prolongation, which meets a similar anterior one of the coracoids, separating the intervening foramina. They appear to form about one-third of the walls of the glenoid cavity, and have a constricted base, as in some *Plesiosauria*, applied to the extremity of the coracoid. The form of the glenoid cavity cannot be readily ascertained from the absence of the scapula. What we have of it would suggest the existence of a fore limb of comparatively little power, though no remains of such have been found. The acetabulum is smaller than the glenoid cavity; this point, with the obvious source of propulsive power in the tail, renders it probable that the posterior limbs were the weaker of the two, if any existed. But there is no trace of sacrum, nor of any modified diapopyses for support of an ilium.

The ischia are flat, sub-triangular bones, with a long median line of junction, and communicating anteriorly with the posterior prolongation of the pubic plate. Their postero-exterior margins project well backward. The pubes are broad plates, whose anterior margins diverge from each other. They are broader than the ischia, and form a broad shallow basin for the support of the viscera. The suture defining these elements is obliterated; they are continuous, and form a weak, inferior keel on the median line. A simple curved ilium has been preserved, for which there appears to be a smooth, articular surface on the pubis to which it was attached.

The acetabular portions of these elements are flattened and furnished with convex articular surfaces. The supposed ilia are short, curved bones, resembling that of *Plesiosaurus latispinus*, Ow., or of some of the other species of that family. The shank is flattened cylindric; the distal extremity, dilated, rounded, and flattened. The proximal extremity sub-truncate, or truncate in two or three unequal planes, and with a median pit. It fits well when applied to a concavity on the articular surface of the pubis. The vertebræ above the pelvic arch were furnished with elongate, sub-cylindric diapophyses.

The question as to the presence of posterior limbs remains unsolved. Dr. Turner, having made a second careful search and renewed excavations at the original locality, failed to find any bones which can be assigned to humerus, ulna, radius, carpus or phalanges, or similar elements of the hind limbs. This is the more remarkable, as the pelvic and scapular arches were further completed, and an additional number of ribs obtained. The inferior and lateral regions of the trunk, being then so abundantly discovered, what are we to think of the entire absence of the usually numerous elements of extremities? The glenoid cavities are rather angular, and both were filled with solid, argillaceous matrix. The acetabula are not cup-like, but merely exposures of the narrow, plane extremities of the pubes and ischia; they were covered with thin layers of gypsum; the pieces of the ilia were found imbedded in the mass of matrix which occupied the pelvic arch.

The allied genus *Cimoliasarus*, Leidy, possesses a femur, as described in the work quoted above; it is of shorter and thicker form than in most *Plesiosauri.*

The skeleton so nearly complete would indicate no violent disturbance of the carcass; but if there were, it would be an unusual accident that all of the four limbs should have been removed from their sockets without leaving even fragments.

This genus is well distinguished from *Plesiosaurus* by the peculiarity of the scapular arch. The mesosternum appears to be coössified with the claviculi, and the three elements form a broad breast-plate. If the claviculus was ever united with the scapula as in *Plesiosaurus*, no evidence of it can be seen in the specimen. Both the clavicular and mesosternal elements are broader and more extended anteriorly.

The American genera of *Elasmosauridæ* may be compared as follows:

Posterior cervical vertebræ without diapophyses: cervicals longer, compressed, neck very elongate.

ELASMOSAURUS.

Posterior cervical vertebræ with diapophyses: cervicals quadrate, shorter, depressed, rapidly diminishing in size, hence the neck shorter.

CIMOLIASAURUS.

Professor Owen figures and describes (reptiles of the Cretaceous, Paleontogr. Soc.) a vertebra which very closely resembles the cervical of *Elasmosaurus.* He considers it to be the cervical of a peculiar *Plesiosaurus*, which he calls *P. constrictus*, remarking at the same time, its remarkably inferior pleurapophyses. This I believe to be a species of *Elasmosaurus* or an ally, and to be called for the present *Elasmosaurus constrictus.*

ELASMOSAURUS PLATYURUS, (COPE.)

Leconte's Notes, loc. cit. Proceed. Acad. Nat. Sci., 1868, l. c. 92.
Discosaurus carinatus, Cope. Leconte's Notes, l. c.

This, after *Mosasaurus*, the most elongate of the sea saurians yet discovered, is represented by a more than usually complete skeleton in the Museum of the Academy of Natural Sciences in this city. It was found by Dr. Theophilus H. Turner, the physician of the garrison at Fort Wallace, a point situated three hundred miles westward from Leavenworth on the Missouri River, and some distance north from the Smoky Hill Fork of the Platte River. Portions of two vertebræ, presented by him to Dr. Leconte when on his geological tour in the interest of the United States Pacific Railroad Company, were brought by the latter gentleman to the academy, and indicated to the writer the existence of an unknown Plesiosauroid reptile. Subsequent correspondence with Dr. Turner resulted in his employing a number of men, who engaged in excavations, and succeeded in obtaining a large part of the monster. Its vertebræ were found to be almost continuous, except a vacancy of some four feet in the anterior dorsal region. They formed a curved line, a considerable part of whose convexity was visible on the side of a bluff of clay shale rock, with seams and crystals of gypsum. The bones were all coated with a thin layer of gypsum, and in some places their dense layer had been destroyed by conversion into sulphate of lime.

The scapular arch was found in large part adhering to the bodies and neural spines of a series of the anterior dorsal vertebræ, and was detached from it at the academy. The pelvic arch had been slightly crushed, and the lumbosacral vertebræ forced into contact with the ischia, where they remain. A broken extremity of the supposed ilium was forced into the matrix which supports the ischia. Many of the dorsal and caudal vertebræ were sent, and remain in continuous masses, so that the succession is readily traced, and the true relations of the extremities preserved.

In removing the matrix from beneath the vertebræ, scales and teeth of some six species of *Physoclyst* and *Physostomous* fishes were found, including an *Enchodus* and a *Sphyraena*, the latter indicating a new species which I have called *S. carinata*. These animals had doubtless been the food of the *Elasmosaurus*.

The end of the muzzle was broken from a part or the whole of the cranium, which has not been rediscovered, though Dr. Turner has made careful search. It was found in front of the vertebræ here regarded as cervical, at some distance from them.

The whole skeleton has been under considerable pressure, so that most of the ribs have been pressed flat on the vertebræ; the long parapophyses of the cervicals have most of them been fractured at their bases and compressed, those of opposite sides thus approaching more nearly in the form of chevron bones than they otherwise would have done. The proximal cervicals are obliquely flattened by the pressure; the other cervicals have the bodies naturally flat, with the articular surfaces much less so than the median portion. Some of the caudals are obliquely distorted.

Description—Vertebræ.—The neck may be safely assumed as a point of departure, as it consists of above sixty mostly continuous vertebræ, which graduate to an atlas of very slender proporticns. Most of them preserve more or less developed parapophyses. At the posterior extremity of this series, sixteen are perfectly continuous, and in this portion a great gradation in form is apparent. The anterior are narrow, compressed, and similar to the more distal cervicals in the elevated position of the lateral angle; the anterior are subquadrate, thick, and with lower lateral rib, and stronger (?) pleurapophysis. In these respects the latter resemble the dorsals which follow, toward what I believe to be the tail. Four anterior dorsals are in one mass (figured in Plate 3;) in this series the lateral angle first approaching is finally lost in the margin of the rib-pit, the posterior thus resembling other dorsals. There can be, so far, little doubt that the anterior and posterior extremities of the masses are correctly interpreted.

In a series of four anterior dorsals, which, like the preceding, are in their original continuous mass, those of one extremity have centra rounded in section, with inferior rib-pits; those of the other have quadrate centra and elevated diapophyses; the former have the character of the first dorsals, the latter of the median dorsals. The posterior dorsals and anterior caudals form in like manner a continuous series of eleven vertebræ, fractured in four places. In them the diapophyses steadily descend, reaching the inferior plane in the last, thus with the reduction of the venus foramina to one, at the seventh, indicating the point of transition from dorsal to caudal series. The zygapophyses preserve the usual arrangement, but are much compressed, so that the posterior or downlooking are confluent, and scarcely separated by an emargination.

The neural spines at their bases have a slight posterior obliquity, and the superior portion leans strongly in the anterior direction. The inferior limbs of the cervical pleurapophyses appear to be entirely wanting. The articular faces for the chevron bones are seen at the extremity of the inferior rib of the caudal.

Of the cervicals there are both axis and atlas. Of the caudals, probably the distal half at least is lost. A single vertebra near the middle does not relate to either of those anterior or posterior to it. There are, therefore, at least four lost from that region also.

There is a considerable interruption immediately anterior to the last dorsal vertebra. Three large vertebræ, with long diapophyses belonging here, were imbedded in the hard matrix which protected the pelvic arch. These are far from relating immediately to the vertebræ preserved before and behind them. I estimate the number missing as follows: Seven of the fourteen dorsals preserved have more or less elongate diapophyses. In the *Plesiosauri*, vertebræ of this character are much more numerous; in *P. homalospondylus* Owen gives seventeen. If we add ten to the series in the present species it will give the abdominal space between the adjacent margins of the o. o. pubis and coracoidea an extent equal to the length of the plevic arch. This is relatively shorter than in the *Plesiosauri*. Dr. Turner found that a space of "three or four" feet intervened between the two portions of the skeleton, which was otherwise continuous. I think ten an average number to represent safely the missing dorsals.

From the cervical proximal regions probably three vertebræ are missing from two interruptions. The remainder of the servical series exhibits three interruptions. Most of the proximals have been broken medially, leaving the articulations solid, an advantage in determining their continuity. Three vertebræ and one-half are thus found to be missing in this region.

The whole number of vertebræ preserved and lost, with the relative lengths of each, may be stated as follows:

	Present.		Lost.		Total lengths.
	No.	Length in.	No.	Length in.	
Cranium	.....	....	.....	24.	24.
Cervicals	68½	257.5	3½	22.3	279.8
Dorso-lumbars	14	55.10	10	37.6	93.4
Caudals	21	60.4	30	60.	120.4
Total	103½		43½		517.6

This gives the total length to the animal of forty-three feet two inches, which, increased by the amount taken up by intervertebral cartilages, will give roundly about forty-five feet. Of this, twenty-two feet must be reckoned to the neck.

The cervical vertebræ are assumed to commence where the rib pits cease, and the continuous lateral processes commence. This point is ascertained with difficulty on the specimen. It is, however, perhaps the same point where the longitudinal lateral ridge leaves the upper margin of the rib pit; and it was to the series of vertebræ which pass this point, the scapular bones, the clavicle and coracoid, were found attached. On the anterior dorsals the inferior margin of the rib pit is most prominent, and is finally produced in a flat thin process which is directed obliquely downwards. Both these and the posterior ribs are crushed on the centra and project obliquely below them; their mode of attachment is thus rendered rather obscure. A similar structure exists in the posterior cervicals of *Cimoliasaurus*, while on the anterior dorsals, or where the rib-origins are on the lower plane, short, thick diapophyses support the ribs. The proximal cervicals are remarkable for their compressed and elongate form. They are for a considerable distance longer than any dorsals. The lateral longitudinal ridge rises successively nearer to the neural arch and disappears. The articular surfaces are vertically oval, flattened above and below. The inferior faces are slightly grooved in line with the venous foramina. These vertebræ diminish in length, and, after the posterior third of the series, materially in depth. They diminish to terminal ones of very small size. In most the decurved (?) pleurapophyses are broken near the base, but the basal portion of various lengths generally adheres. They are as wide as a rib and scarcely half as thick. On some of the most anterior vertebræ they are quite short and broad antero-posteriorly. They have much greater antero-posterior extent on the terminal than the proximal cervical centra, having a base five-sixths the length of the latter. The zygapophyses have relatively a larger size on these than any other vertebræ. In such the centrum is less compressed, though with concave sides, and with a section rather quadrate.

Measurements.—The cervical vertebræ from the sixty-sixth to the thirty-ninth are all longer than the dorsals; they commence four inches in length, increase to five, and diminish to four again.

	Inches.	Lin.
Length of sixty-third cervical	4	9. 2
Depth articular face of the centrum	3	8.
Width articular face of the centrum	3	10. 2
Total elevation ninth do	2	9.
Anterior-posterior diam. third cervical	2	2.
Transverse diam. third cervical	2	11.
Length head of rib	1	9. 7
Width head of rib	1	3.
Width shaft of rib	1	10. 5

Many of the *ribs* preserved have been pressed upon the vertebræ and crushed.

The first *dorsal* is that vertebra which first presents a distinct articulation for a rib. The diapophyses are never much elevated above the centrum and are longest on the thirteenth, (inserting seven supposed to be lost.) Their form is stout and much depressed, and distally expanded. They diminish gradually, and on the third are represented by a longitudinal, slightly-concave, articular surface, somewhat similar to those of the caudals. This surface is bounded above and below by a longitudinal angulation; the superior is first distinct on the first, and bounds the articular surface last on the third. They give the transverse section of the posterior cervicals a pentagonal form; that of the anterior dorsals is nearly circular. The latter are strongly constricted medially, and the articular faces are slightly concave. The external surface near the included angle is coarsely ridged, in conformity with coarse cellular texture of the spongy bone. The venous foramina gradually become more widely separated, approaching each other again on the posterior cervicals. On the dorsals they occupy the bottom of a more or less pronounced concavity. These concavities, on the posterior dorsals, are bounded externally by a strong obtuse longitudinal angulation, giving a quadrate outline to the section of the centrum in this part of the series.

The posterior cervicals are not readily distinguished from the anterior dorsals. In the latter the ribs appear to be present, of reduced length, judging from the smaller size of the remaining heads. The articular pits continue to descend till their lower marginal ridge is the inferior lateral angle of the vertebra. On such vertebræ the inferior surface is flat. The neural spines on dorsals and posterior cervicals are of great height as well as antero-posterior width, and they allow a very narrow interval between them.

	Inches.	Lin.
Antero-posterior diameter (?) twelfth dorsal	3	7.2
Transverse diameter articular surface	4	10.
Vertical diameter articular surface	4	2.5
Neural canal and spine (latter broken)	5	3.5
Length diapophysis twelfth dorsal	4	
Width diapophysis at middle	1	10.
Antero-posterior diam. (?)eleventh dorsal	3	4.5
Transverse posterior of articular face	5	3.
Vertical posterior of articular face	3	10.
Transverse posterior of neural canal		10.2
Transverse posterior of articular face, third dorsal	5	2.5
Elevation centrum, arch and spine, second dorsal	11	9.
Elevation upper edge zygapophysis, second dorsal	6	
Length zygapophysis, upper edge, second dorsal	1	10.2
Length centrum, last cervical	4	
Width centrum articular face cervical	5	3.
Elevation neural arch and spine cervical	7	9.
Antero-posterior width neural spine of cervical at zygapophysis	3	7.

The *caudal vertebræ* have slightly concave articular surfaces, which are not bounded by groove or ridge. The neural arches have flat sides, and there is no longitudinal ridge above the diapophyses. The neural spines are elevated, the margins of those of the adjacent vertebræ close together. The diapophysis is very short and wide, terminating in a large oval concavity for the pleurapophyses. Each limb of the chevron bone is attached to an articular surface on the lower posterior face of the vertebra, at the extremity of a strong inferior ridge. These inferior ridges are rather close together, and distinguish the vertebræ from those of *Cimoliasaurus magnus*, where they are wanting. They are absent on the anterior seven of the caudal series. The diapophysis is nearer the anterior than the posterior face of the vertebra. The venous foramen is single and median on all but the last six cervicals.

	In.	Lin.
Antero-posterior diameter of fourth caudal	2	4.
Transverse-posterior	3	10.5
Total elevation	8	
Vertical diameter centrum	3	1.5
Anterior-posterior diam. diapophysial pit	1	9.2
Length ninth caudal	1	7.5
Transverse diameter articular face	1	6.
Vertical diameter articular face do	1	2.7

Heads of fourteen *ribs* are preserved, and a great number of shafts. The heads are simple, with elongate oval articular face. They are oblique in the narrow direction, and frequently in their length also; the margins are somewhat everted. The extremities of the diapophyses of the larger dorsal vertebræ are transverse, some flattened, the others more oval; the more anterior are subtriangular, and the rib pits on the first dorsals are subround or vertically oval. Thus the heads of the ribs also vary. The shafts are all flat, probably more so from pressure. They are frequently curved in the direction of the compression, which suggests a vertical head. They, however, are probably more or less distorted, and the plane of compression changed. No well-defined distal extremity of a rib can be made out, nor have anything like abdominal ribs been preserved.

The *scapular arch* is remarkable for its large clavicles (or procoracoids.) As preserved, the latter are quite convex downwards, both antero-posteriorly and transversely, while the coracoids are equally concave in both directions. The clavicles have a remarkable external flat projection, which is separated from the glenoid cavity by a deep sinus. The glenoid cavity is bounded by an elevated ridge, which sends a branch along the claviculo-coracoid suture to the precoracoid foramen. This foramen is relatively of small size, and is a longitudinal oval; the two are separated by an isthmus composed equally of processes of clavicle and coracoid. The coracoids are very thin except in a transverse portion, which extends across behind the precoracoid foramina; a strong elevated rib extends across the posterior face at this point. The outer margin of the coracoid is thickened, rounded, and slightly concave.

	In.	Lin.
Greatest antero-posterior length scapular arch	33	6
Greatest antero-posterior length clavicle	14	9
Greatest antero-posterior length glenoid cavity	6	9
Greatest antero-posterior length precoracoid foramen	7	3
Transverse extent of claviculi	27	
Transverse extent of coracoidea	16	
From acetabulum to foramen	7	6

The form of the posterior margin of the coracoidea is unknown, and they are much broken on the inner margin. They may have been considerably longer than in the accompanying cut.

The greater part of the *pelvic arch* appears to be preserved. From the obliquity of the median suture and from the form of the pubes, as they are preserved on a large nodule of indurated clay, it is evident that they have formed a boat-shaped support to the abdominal viscera, with an obtuse keel on the median line below. The following diagram will explain the relation of its parts:

	In.	Lin.
Greatest antero-posterior length	25	
Greatest antero-posterior length pubis	13	6
Antero-posterior median length to notch of ischia	7	
Length coracoids behind notch	4	6
Greatest width pubes	27	6
Greatest width ischia	21	

The anterior and lateral portions of the pubes are very thin, as are also the median posterior portions of the ischiadic plates. The pubic bones are thickest on the posterior margin; they present a downward projecting median convexity near the anterior end. Depth of the articular face, 2 in. 8 lin.

The superior surface of this arch was brought to light by the exertions of my friends, B. Waterhouse Hawkins and William M. Gabb, who removed a large mass of matrix which fortunately accompanied and protected it. This presents a transverse thickening extending across it, and continuous with the posterior margin of the clavicles. A median longitudinal thickening extends from this to the anterior emargination, embracing in its angle with the transverse, a shallow concavity. The posterior projection which is continuous with the median part of the ischia is strongly deflexed behind the transverse rib, and is continuous with the basin-like concavity formed by the united pubes. The glenoid surface of the pubes is a sigmoid, while that of the ischia is regularly convex. The articulation of the ilium has been exclusively with the former.

Of the pleurapophysial portion of the two arches nothing appears to be preserved except two lateral, symmetrical, long bones. One was found imbedded in the mass carrying the pelvic arch, and they articulate well with the pubes; but the articular extremity is too short to articulate with ischia at the same time. Though they resemble the inferior view of the procoracoids, they represent the ilia of *Plesiosaurus*. The head is subdiscoid, rather flat, slightly projecting eccentrically with a ligamentous pit. The articular surface is very oblique to the axis of the shaft, and is separated from the surface by a marked angle all around. Nothing like a trochanteric ridge is apparent in this bone.

	In.	Lin.
Length in middle of curve	9	9
Diameter at head	3	3
Diameter distally on curve	6	
Diameter distally straight	4	

The shaft is flattened cylindric; much flattened nearest the proximal extremity. The latter is very oblique to the shaft and slightly convex near the proximal margin.

The end of *the muzzle* preserved includes also the symphysis and parts of the rami of the mandible. The parts have been crushed together, and the ends of the teeth broken off. The alveoli of the two jaws incline at a narrow angle to each other; hence the teeth, which alternate, cross each other near the middles of the crowns. The parts preserved appear to belong to the premaxillary bone, though no suture can be found and the bony walls are so thin as to render their obliteration a probability. There is a keeled ridge along the middle line above, which is not continued to the margin of the bone. The form of the muzzle is narrow, the sides subparallel near the tip, which is elongate rounded. The mandibular symphysis, however, is not very elongate, as the rami are given off at three inches from the tip. The latter appear to have been quite slender from the various small sections or pieces sent with the muzzle. The premaxillary border of 4 in. 7 lin. exhibits eight teeth, or their alveoli, of which the median two are close together, and not separated by any mandibulars. The sections of the teeth are round or oval, and their sizes are irregular, probably on account of differing age and degree of protrusion. The diameters at alveolar margin vary from 6 lines to 3. Their form is slender conic, or with the root slender fusiform, and the pulp cavity is small and median, sometimes cylindric, and sometimes narrowed. The surface, from a short distance above the alveolar margins to the tip, is marked with acute, thread-like ridges, which are sometimes interrupted, and sometimes furnished with short branchlets. They are more or less undulate, and do not unite, but simply cease as the tip of the tooth is approached. The latter is smooth without lateral cutting edges. The width of the mandible at the commencement of the rami is 3 in. .05 lin.; of the muzzle of the seventh tooth 3 in. 7.5 lin.; at the third tooth 2 in. 4.2 lin.

General Remarks.—The tail is a powerful swimming organ, more or less compressed in life; hence the specific name, which means flat-tailed.

The danger of injury to which such an excessively elongate neck has been exposed, would render the recovery of a perfect specimen like the present an unusual accident. The neural spines of the dorsal region are so elevated and closely placed as to allow of little or no vertical motion of the column downwards, while those of the cervical and caudal region being narrower, the elevation of the head is quite possible, and an upward flexure easy.

The habit of this species, like that of its nearest known allies, was raptorial, as evinced by the numerous canine-like teeth, and the fish remains taken from beneath its vertebræ.

The general form of this reptile, whether it was furnished with large posterior limbs or not, was that of a serpent with a relatively shorter, more robust, and more posteriorly placed body than is characteristic of true serpents, and with two pairs of limbs or paddles. It progressed by the strokes of its paddles, assisted by its powerful and oar-like tail. The body was steadied by the elevated keel of the median dorsal line, formed by the broad, high neural spines. The snake-like neck was raised high in the air, or depressed at the will of the animal, now arched swan-like preparatory to a plunge after a fish, now stretched in repose on the water or deflexed in exploring the depths below.

Differences from other Sauropterygia.—The only genus with which it is necessary to compare this present one is *Cimoliasaurus*. The following may be noted as generic distinctions: The series of cervicals rapidly diminishes in *Cimoliasaurus* in absolute size and in relative length of the vertebræ, which are not compressed. In the present genus they maintain a similar and increased length for a considerable distance, diminish in length very gradually and are much compressed. The diapophyses of the dorsal vertebræ, as they descend, in *Cimoliasaurus*, continue well developed until they attain the inferior planes of the centrum, and have there a downward direction. In *Elasmosaurus* they cease while yet on the middle of the centrum and are replaced by pits throughout the remainder of the length.

The neural canal is everywhere markedly larger in *Cimoliasaurus.*

As the characters of lesser significance may be added, that in *Cimoliasaurus magnus* the dorsals with elevated diapophyses are considerably larger in the centra than those in which they are situated lower down. In *E. platyurus* these vertebræ are of relatively equal length.

The cervical pleurapophyses in *C. magnus* are anteriorly considerably stouter and less flattened; the same applies to more anterior vertebræ, where they are flatter in both.

In comparing this species with the *Cimoliasaurus grandis*, Leidy, from Arkansas, we observe, first, the generic character of the strong inferior diapophyses in the latter. That species marks itself also as a preëminently short-necked form, as these anterior dorsals are even shorter than in *C. magnus*, being nearly twice as wide as long. The depth of the articular faces is also relatively greater than in the *E. platyurus.*

Localities.—This species has been found in various parts of Kansas besides that whence the specimen above described was procured. Professor B. F. Mudge obtained vertebræ from a point thirty miles east of Fort Wallace, which probably belong to this animal.

PYTHONOMORPHA.*

This order is more extensively represented in the cretaceous beds of Kansas than any other, no less than six species having been determined up to this time. A seventh, *Liodon dyspelor*, Cope, has been discovered

* For the definition of this order see Trans. Amer. Philosoph. Society, 1869, p. 175, and Proc. Boston Soc. N. Hist., 1869, p. 253.

in the continuation of the same yellow chalk formation in the Territory of New Mexico, and will probably be found in Colorado and Kansas.

The genera to which these species belong are *Clidastes*, Cope, *Liodon*, Owen, and *Mosasaurus*, Conybeare. The two latter occur also in the cretaceous strata of Europe. While *Mosasaurus* is most abundantly represented in the cretaceous of the eastern parts of the United States, *Liodon* abounds much more in the central regions.

MOSASAURUS, (CONYBEARE.)

MOSASAURUS MISSURIENSIS, (HARLAN.)

(*Ichthyosaurus* do., Harlan, Trans. Amer. Philos. Soc., IV, 405, Tab. XX, 1834. *Batrachiosaurus*, Harlan. *Batrachiotherium*, Harlan. *? Mosasaurus neovidii*, Meyer. *? M. maximiliani*, Goldfuss. *M. missouriensis*, Leidy, Cretac. Rept., 1865. Pl. VII, figs. 15, 16, 17, 18.)

The centra of the vertebræ of this species are moderately depressed. The centra of the caudals, posterior to the disappearance of the diapophyses, are as wide as deep, and of nearly similar length, and with anchylosed chevron bones. A fine cranium figured by Goldfuss shows the crowns of the teeth to be subcylindric, incurved, and facetted; but it is not certain that it belongs to this species.

An unusually perfect specimen of this species, or one allied to it, was recently exhumed by W. E. Webb, near the town of Topeka in Kansas. My friend Professor J. Parker, of Lincoln College, of that place, informs me that it is seventy-five feet in length, and the gentleman who discovered it, that it measures eighty feet. Its mandibular rami are stated by the same person to measure five feet. Measurements of the vertebræ indicate them to be of a size quite similar to those of large individuals which have been discovered in the green-sand of New Jersey. They measure as follows, as stated on photographs by my friend W. E. Webb:

	Inches.
Diameter cervicals centra only	2.5
Diameter dorsals, with diapophyses	7
Diameter lumbars	2

These proportions illustrate again the Ophidian or eel-like form of this genus, and the relatively large size of the head.

The teeth resemble in size those of large specimens of *M. dekayi*.

LIODON, (OWEN.)

(Proceed. British Assoc. Adv. Science, 1841, p. 144. Cope, Trans. Amer. Philos. Soc., 1869, p. 200.)

This genus is characteristically American; four species are known from the western cretaceous, four from the eastern, (*L. mitchillii*, *L. validus*, *L. sectorius*, and *L. laevis*,) and two from the southern, (*L. perlatus* and *L. congrops*;) one species (*L. anceps*) is British. Some very large species (*L. dyspelor*, *L. proriger*) belong to it, while *L. congrops* is one of the smallest of the order.

LIODON PRORIGER, (COPE.)

(Transactions Amer. Philos. Soc., 1869, p. 202. Tab. XII, Figs. 22–24. *Macrosaurus proriger*, Cope, Proceed. Ac. Nat. Sci., Phil., 1869, p. 123. Leidy, Cretac. Rept. II, 15, 16, [caudal vertebra.])

The history of this large *Mosasauroid* was originally based on material in the Museum Comparative Zoölogy, Cambridge, Massachusetts, brought by Professor Louis Agassiz from the cretaceous beds in the neighborhood of Fort Hayes, Kansas, and near the line of the Southern Pacific Railroad. It consists of the greater part of the muzzle from the orbits, with the right dentary and left pterygoid bones nearly complete; one cervical vertebra, (with hypapophysis,) one dorsal, one caudal with diapophysis, and ten caudals without diapophysis. Smaller portions of the skeleton have also been found by Dr. F. V. Hayden and Professor B. F. Mudge.

The characters presented by the vertebral column indicate an excessively elongate reptile; the transverse diameter of one of the distal caudal vertebræ is less than one-fifth that of a proximal with short diapophysis, while four consecutive ones of the former show but little variation in dimensions. This diminution amounts to $\frac{2}{7}$ of a transverse diameter of the larger form. With this ratio as a basis, fifty-three $\frac{2}{3}$ vertebræ would form a complete series from caudals one-half the diameter of the last of the four, to the proximal caudal above mentioned. There have been, no doubt, several caudals in advance of the latter, as the diapophyses are small. From the slow rate of diminution of the columns of other species examined, it may be supposed that sixty caudal vertebræ is below rather than above the true number.

The cervical and dorsal vertebræ have been slightly crushed as they lay on the side, and present a narrower diameter than is normal; the cup of the cervical has not been distorted, and is deeper than wide, presenting the character of *Macrosaurus*. The rudimental zygosphen consists of a continuation of the roof of the neural canal in front, to adapt itself to the inner face of the down-looking zygapophysis of the preceding vertebra. The latter is thus received into a groove on the inner side of the up-looking posterior zygapophysis. The dorsals and caudals exhibit with the cervicals that minute, sharply-defined rugosity which characterizes all the projecting margins, especially those of the hypapophysis and diapophyses in this genus and *Clidastes*. The whole surface of the cervical is marked with either inosculating striæ or impressed punctæ. The same character marks the cranial bones, though they do not present such rugosity as the vertebræ.

The proximal caudal presents a subhexagonal section, of which the inferior and supero-lateral sides are longest; articular faces about as broad as high. A broad, smooth space between the chevron bones. Diapophyses with broad, ovate, transverse section.

A caudal without diapophyses, anterior to the middle of the series, estimated by the size, is but slightly deeper than long, and with parallel lateral outlines of the articular faces. The neural arch is very much narrowed antero-posteriorly, but has a greater transverse extent at its lower part; above the spine is much compressed, but not widened. The zygapophyses remain as rudiments just above the small neural canal, but do not probably touch each other. There are two anterior and two posterior narrow ribs on the upper portion of the neural spine. The more distal caudals have wider neural spines, and the arch also has a greater antero-posterior extent. The zygapophyses are scarcely traceable and the neural spine is strongly striate. The reverse arrangement is observed in *Clidastes propython*, where the neural spine of the proximal caudal has considerable extent, while those of the posterior and distal vertebræ are almost cylindric, especially the neurapophyses.

Dimensions.

	Inches.
Dorsal, length	3.35
Dorsal, width cup	2.5
Dorsal, depth cup	2.77

	Inches.
Proximal caudal, length	2.14
Proximal do., width cup	3.43
Proximal do., depth cup	3.23
Caudal without diap., No. 1, length	1.6
Caudal without diap., No. 1, depth cup	2.65
Caudal without diap., No. 1, width cup	2.6
Caudal without diap., No. 1, height neural canal	.4
Caudal without diap., No. 1, antero-posterior width neural spine	.8
Caudal without diap., No. 2, length	1.2
Caudal without diap., No. 2, depth cup	2.15
Caudal without diap., No. 2, width cup	1.86
Caudal without diap., No. 2, width neural sp. (antero-posterior)	1.07
Caudal without diap., distal, length	.5
Caudal without diap., depth cup	.85
Caudal without diap., width cup	.64
Caudal without diap., distal; diameter, antero-posterior, of neural spine	.40

The points of attachment of the chevron bones on the distal vertebræ are strongly-marked pits; on the anterior, the anterior margins of the pits are raised and continuous with the chevrons.

The muzzle presents the usual characters of the large *Mosasauroids*, but adds a peculiarity in the prolongation of the premaxillary bone into a cylindric mass forming an obtuse beak beyond the premaxillary teeth. The bone is narrowed anteriorly, and does not descend regularly as in *Mosasaurus* sp., but continues to its abrupt and narrow termination described. The extremity is deeper than wide. Immediately in front of and between the anterior premaxillary teeth, a short acuminate projection interrupts the surface, and in front of this, a transverse depression. Above, the surface becomes flattened, and presents two shallow longitudinal depressions continuous with the nostrils. Where the premaxillary rather suddenly contracts into its spine, it is materially wider than the maxillary on each side of it; in *M. missuriensis* it is narrower, according to Goldfuss. The maxillary border of the nares is rather suddenly concave at the anterior extremity of the nares, narrowing the maxillaries; the latter gradually widen by the expansion of their inner margins.

No part of the frontals is preserved, but a considerable part of the pre-frontal remains. It unites by a very coarse overlapping suture with the maxillary, whose outline forms an irregular chevron with the apex pointing forwards in the middle of the maxillary bone. This, it will be seen, is very different from the form given by Goldfuss in the *M. missuriensis*, where the most anterior point of the suture is on the nareal margin. The external margin of the bone behind is contracted considerably within the maxillary border, previous to its outward extension toward the orbit. This is much less marked in the *Clidastes propython*, but is distinct in *M. missuriensis.*

The maxillo-premaxillary suture gradually descends to the alveolar border to the extremity of the maxillary bone, where it descends abruptly, forming an interlocking suture quite different from that squamosal type already observed in other species of the order. The length of the premaxillary anterior to this point is three-fourths the length of the same to the beginning of the nares.

The number of teeth on the maxillary bone was probably thirteen; twelve alveolæ and bases remain, and one is added in the position of the posterior of *M. missuriensis*, if such existed; this may be questioned in consideration of the small number of mandibular teeth. Premaxillary teeth two on each side, the anterior with bases separated only by a groove. Throughout the whole series the bases of the teeth are considerably more exposed on the inner than the outer side.

The crowns are everywhere sub-cylindric at the base, the inner face more convex than the outer. Posteriorly there is a posterior cutting ridge, as well as a marked anterior one, both minutely crenulate, but the former disappears till in the anterior teeth there is only an anterior edge, the posterior face being convex and continuous with the inner. There is a trace of cutting edge on the outer portion of the extremity of the crown in the most anterior teeth. The anterior ridge remains very strongly marked. The surface is quite rough with longitudinal ribs, of which eight may be counted on the outer aspect of the second maxillary. These are not strongly marked, and are separated by concave facets. The basal part of the crown is marked by numerous fine sharp striæ, which are most distinct on the inner face.

The external face of the maxillary bone presents three series of foramina. These rise superiorly on the premaxillary, and increase in number and become irregular on its extremity.

The ramus of the mandible is massive, and differs from that of *Mosasaurus giganteus* in continuing its proportions to its extremity. Its depth at the latter point is as great as the sixth tooth from the front. It is prolonged beyond the first tooth in correspondence with the prolongation of the premaxillary. This extremity is compressed and obtuse; its inner face is very rugose, as though there had been a closer union at the symphysis than usual, though it would not appear to have been other than ligamentous. The groove for Meckel's cartilage is very large and has been exposed below the last two teeth, as the splenial terminates at the third. Two series of foramina on the external face of the ramus. There are alveolæ and bases for thirteen teeth on the dentary bone. This, it will be observed, is one more than in *M. gracilis*, and one less than in other species of *Mosasaurus*. The posterior extremity of the dentary shows its marks of reception into the notch of the coronoid; it is more compressed and less club-shaped than the corresponding part of *M. mitchillii*, and would indicate less lateral flexibility than in some other types.

The right pterygoid is of less elongate form than in some other species. It presents the sutural face for union with the palatine on the outer anterior extremity, and narrows to an apex a little in advance. The dentigerous face is widest at the anterior third the length, where the outer margin is expanded. This then contracts and is compressed vertical at the tenth tooth, where it is broken off. The transverse process is given off a little anterior to the ninth tooth. The interior face of the bone is a vertical plane, without projection, except a slight obliquity at the anterior extremity, and it is clear there has been some interval between this pterygoid and its fellow. The superior margin is obtusely rounded.

The bases of the pterygoid teeth are exposed for two-thirds their length, on the outer side of the bone, thus approaching the *Platecarpus*. The antero-median are large, and the anterior most closely placed. Their crowns are strongly recurved, round in section, and with a fine sculpture of straight striæ, most marked near the base and on the inner side. They are more spaced posteriorly than any other species except *M. mitchillii*, and are relatively larger than in any except the same species. They have not the compressed form with basal shoulder, characteristic of the *M. dekayi*.

Measurement of muzzle.

	Inches.
Length of fragment	31.
Length from end muzzle to pre-frontal	21.5
Length from end muzzle to nares	11.75
Length from end muzzle to maxillary	5.75

	Inches.
Length from end muzzle to first tooth	2.5
Width of muzzle at end	1.5
Width of muzzle at anter. extremity nares	8.
Width of premaxillary at anter. extremity nares	3.3
Width of maxillary between tenth and eleventh teeth	3.2
Depth mandible at extremity	2.5
Depth mandible at sixth tooth	3.5
Depth pterygoid at transverse process	2.5
Width pterygoid at transverse process	1.4
Width pterygoid in front	2.2
Length pterygoid anterior to transverse process	7.2
Length crown fifth pterygoid tooth	1.
Length crown second maxillary tooth	1.9
Diameter crown second maxillary tooth at base	1.1

The vomers are, as usual, separate and narrow. They are in close contact from the second maxillary to the second premaxillary tooth. Thoughout this part of their length they are embraced by posteriorly produced vertical laminæ of the premaxillary bone. These laminæ unite just behind the second premaxillary teeth and form a single prominent keel, which disappears between the first premaxillary.

LIODON MUDGEI, (COPE.)

(Proc. Amer. Philos. Soc., 1870, Dec.)

I am not quite sure whether this species belongs to this genus or to *Mosasaurus*. The characters of its quadrate bone, size, &c., induce me to refer it provisionally to the former. Its determination rests on a series of specimens from the yellow chalk at a point six miles south of Sheridan, Kansas. They consist of three vertebræ and fragments of atlas, with numerous portions of cranium and proximal extremity of scapula. The parts of cranium preserved are the frontal bone without the anterior extremity, and with the adjacent parietal almost complete, parts of the basisphenoid, the suspensorium, the ossa quadrata, and the greater part of the articular. The frontal is flat, with thin edge, longitudinally hollowed on each side of the median line, which is marked by a low but acute keel. There is an abundance of foramina and delicate grooves on the surface, and posteriorly elevated striæ, which converge to the median keel. The median square projection of the border of the parietal is in advance of the lateral portion of the same, and not behind it, as in *Clidastes propython*. The fontanelle is large. A marked feature is that the parietal crests unite into a low median ridge a short distance behind the fontanelle, and are not, as in *Clidastes propython*, separated by a horizontal plane. The sutures of the bones forming the side of the brain-case are very obscure. Nevertheless, it appears that the descending margin of the parietal does not descend to the front of the alisphenoid, but is margined inferiorly by the latter to the post-orbital expansion. No part of the inferior margin of the alisphenoid can reach the sphenoid, as it terminates in a thin edge, except for a short distance medially, where it is broken off.

The inferior aspect of the parietal and frontal bones presents a furcate keel corresponding to the divergent parietal crests, and a very large funnel for the epiphysis of the brain. The olfactory groove is deep and regular.

The articular bone is characterized by the prominent longitudinal crest which descends on the inner side from the front of the glenoid cavity to below the posterior attachment of the coronoid bone, where it terminates in a thin edge. Also by the short distance between the margin of the glenoid cavity (cotylus) to commencement (or end) of coronoid suture, indicating a shortening of the posterior part at least of the cranium. The bone is continued forward only immediately under the coronoid, (*c. f. r. L. ictericus.*)

The proximal extremity of the quadrate is characteristic, and exhibits features intermediate between those of *Liodon ictericus*, Cope, and the typical species of *Mosasaurus*, as *M. fulciatus*, *M. dekayi*, &c. The proximal articular face is much like that of *M. depressus*, (Trans. Amer. Philos. Soc., 1869, p. 187, Fig. 48, No. 3.) The external angle is much smaller than in the Liodons and more anterior; nevertheless it is continued distally as a ridge-like angle separating the antero-lateral from the postero-lateral faces, as in them, and not presenting the gradual blending of the two surfaces, characteristic of the genus *Mosasaurus*. The postero-lateral face is thus flat proximally, and the meatal pit, which is well developed, cannot be seen from the antero-lateral face. The distal part of the quadrate is lost so that I cannot determine the character of the ridges there.

The basal element of the axis bears a strong hypapophysis without articular faces, but very rugose surfaces. The same portion of the atlas is a convex parallelopipedon with median rugose tuberosity, and very rugose extremities. Its surface is not separated from its body anteriorly by a deep groove as in *Liodon*.

The articular facets of the scapula are much broader than in the other species here described, indicating a head or wider articulation of the humerus. No limb bones were preserved.

The vertebræ are too much injured to be characteristic, with one exception. This one is a posterior dorsal, and had had compressed centrum, or, at least, not depressed. The inferior face is convex transversely, and there is a slight concavity below each diapophysis.

Measurements.

	M.
Parietal length	0.074
Parietal width between anterior and crests	.048
Parietal least width	.022
Frontal interorbital width	.092
Quadrate width above	.002
Quadrate length from pit to proximal end	0.023
Articular length, lower edge	.015
Articular depth, in front of cotylus	.035
Articular depth at coronoid	.055
Posterior dorsal length	0.495
Scapula, proximal width	.051

This species differs from all those of *Mosasaurus* and *Liodon*, in which the form of the quadrate is known in the character of that bone. From *L. lævis* and *L. congrops*, in which that element is unknown, it differs in the stouter or less slender vertebræ; from *L. proriger* in its much smaller size.

Its size is a little less than the *L. ictericus* or *L. validus*. It is dedicated to Professor Mudge, in recognition of the valuable results of his investigations as State geologist of Kansas.

LIODON ICTERICUS, (COPE.)

(Proceed. Amer. Philos. Soc., December, 1870.)

Characteristics: External angle of the osquadratum close by the meatus and continued as a rounded ridge, separating the anterior and external faces of the bone. Median posterior ridge not prominent. Centra of dorsal vertebræ depressed. Humerus broad, short.

Description: This species is represented by portions of cranium, as post frontal, susparsorial, pterygoid articular, and quadrate bones; by parts or wholes of seven, vertebræ, which are all dorsals, and by scapula and coracoid, with many elements of the fore limb. The latter includes humerus, radius, a carpal, and numerous metacarpals and phalanges.

The species is first well characterized by the form of the quadrate bone. This element lacks a portion of the ala, and the postero-superior decurved process, but is otherwise perfect. Its form is intermediate between that in *L. validus*, Cope, and *Mosasaurus depressus*, Cope. Its external angle of the proximal extremity is posterior to its usual position, as in the former species, but is less prominent than in it. It extends to near the distal end, disappearing between the extremities of the median posterior and the distal longitudinal angles. The former of these is short and it disappears by a gradual descent distally, in a very rugose margin. The distal longitudinal is short and acute, not prominent at the distal extremity. From the posterior position of the proximal external angle, the alar articular surface is somewhat elongate. The postero-external face above the meatus is proportionately short. The meatal pit is scarcely one-fifth the usual size, so far as determinable from the present surface, but it is possible that the greater part is filled by an impacted mass of bone derived from the adjacent ridge. The margins of the articular extremities and of the ala are striate and papillose rugose. No meatal knob.

The suspensorium is slender. It is peculiar in the great extent of the exoccipital element, which covers the whole superior surface, and extends externally over the opisthotic to the squamosal, concealing the former, except its anterior margin. The proötic sends a small proximal portion only to the superior face.

The pterygoid has been free from its fellow medially. A distal and median portions have been lost; the remaining portions present bases and alveolæ for eleven teeth. The fangs are rugulose and but little swollen; probably five to seven stood on the lost portions. The bases of the crowns are circular. The external process of the bone is slender and flat.

The portion of the mandible preserved includes much of the articular and adherent parts of the angular. The latter forms a narrow band on the lower edge of the external face, and one twice as wide on the inner face. The only characteristic feature is the lowness of the ridge, which descends and extends anteriorly from the anterior margin of the cotylus for the quadratum.

Of the vertebræ several are so distorted by pressure as to be uncharacteristic. Two well-preserved anterior dorsals have transversely oval articular surfaces excavated openly above for the neural canal. One is from a position anterior to the other, and these surfaces are less oval, though still transverse. The centra of both are very concave in profile below, and expand both inferiorly and laterally to the edge of the cup. A deep groove surrounds the base of the posterior face. In the anterior dorsal the neural arch is preserved. It exhibits an approach to a zygosphen articulation more marked than in any other Liodon, and is hence nearer *Clidastes* in this respect, as well as in the slender pterygoids. A zygosphen is not separated from the zygapophyses, owing to their connection by a lamina of bone. The notches at the posterior end of the arch for this prominence are marked. The neural spine had a strong anterior ala, the base of which extends to the summit of the neural arch. It presents a fine striation vertical to the centrum and oblique to the edge of the bone, as is seen in *C. propython*, Cope. The diapophysis on this vertebra looks obliquely upward and carries a vertical articular surface which is concave behind. The line of its lower extremity falls the depth of the neural arch below the latter, and of its upper to the apex of the canal in front. The more posterior vertebra has as usual a broader articular rib surface, the diapophysis being flattened above and below. The marginal and angular surfaces are striate-rugose on these and the other vertebræ. One of the free hypapophyses of a cervical is preserved. It has a subtrigonal section, and is longer than wide, and obtuse. Its posterior faces are exceedingly rugose.

A cervical rib is compressed and short. Head narrow, long, simple, the adjacent sides striate-rugose. Sides with a shallow groove.

The scapular arch is represented by an entire right scapula and proximal part of right coracoid. The former is broader than in any of the species in which I have seen it (four only) and is flat, and above, thin. Its anterior extension is greatest below, its posterior above, at the superior angle. The lower posterior margin is strongly concave and thickened. The antero-superior margin is a regularly convex arc of more than 180°. The lower portion in front is on a different plane and is the rudimental acromion. The articular surface with the scapula is rugose, and the glenoid cavity not less so.

The proximal portion of the coracoid is flat. It presents the usual foramen near the anterior margin, and the shorter concavity of the anterior margin leads to the belief that the anterior extremity of the bone is the more prolonged, as in *Clidastes propython*.

The glenoid cavity is not concave, but merely two adjacent flattened rugose surfaces.

Consequently, the humerus has no head, but merely an elongate articular surface, which exhibits a median keel and a short, angular expansion near the middle. This bone is of remarkable form, more resembling that I have described in *Clidastes propython** than any other, and very different from that described by Leidy in *Platecarpus tympaniticus*. It is a broad, flat bone, expanded at the extremities in one plane, distally, so as to be as wide as long. In the present individual it is crushed by pressure, so that its thickness is not readily determinable. Its external surface rises into a crest medially at the narrowest portion, which continues to the lateral angle of the proximal end, following parallel to one of the borders. A moderate thickening exists on the opposite side, a little beyond the extremity of the crest. Strongly rugose striæ extend to the edges of the articular faces. An oval rugose muscular insertion exists on the least prominent of the distal angles, and not on a process, as in *C. propython*.

A bone which, from its analogy to the *radius* of the last-named species, I suppose to be that bone, accompanies the others. It is flat, truncate proximally, and with nearly parallel borders on the proximal half. Distally it is obliquely expanded, the outline forming a segment of an ellipse whose axis is oblique to that of the bone. Its extremities are rugose striate.

One *carpal* remains; it is a quinquelateral bone, one side being marginal and concave. Perhaps it is the intermedial. There are several elements which are probably metacarpals. The general structure of the

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* See Trans. Amer. Philos. Soc., 1869, 219, Tab. XII, Fig. 17.

whole limb may be determined from these and from the numerous *phalanges.* The former are flattened and with oblique extremities; the latter more cylindric with a transverse truncation. Both have a median contraction, which becomes less marked in the distal ones; these are also more cylindric, entirely so at the distal extremities, which are concave. All of these elements are rod-like, much more slender than any of those figured by Cuvier or Leidy. Those immediately following the metacarpals are flattened, but thicken distally.

The number of *digits* cannot be readily determined, but four may be certainly distinguished. The general similarity in construction of the manus to that of a cetacean mammal is noteworthy.

Measurements.

	M.
Length suspensorium (anteriorly)	0.111
Width suspensorium medially	.031
Quadrate, greatest length	.099
Quadrate, width of ala	.066
Quadrate, thickness behind	.03
Quadrate, length of distal extremity	.043
Pterygoid, length six alveoli	.055
Anterior dorsal, length centrum	.059
Anterior dorsal, width cup	.0515
Anterior dorsal, depth	.038
Anterior dorsal, expanse poster. zygapophyses	.0395
Anterior dorsal, expanse diapophyses	.091
Anterior dorsal with neural canal	.0135
Anterior dorsal, depth neural canal	.011
Posterior dorsal, depth ball	.049
Posterior dorsal, width ball	.0425
Posterior dorsal, length centrum	.0555
Posterior dorsal, expanse diapophyses	.088
Scapula, length	.145
Scapula, width proximal	.07
Scapula, width median	.112
Coracoid, width proximal	.066
Humerus, length	.154
Humerus, width proximal	.119
Humerus median	.075
Humerus, distal (restored from *C. propython*)	.158
Radius, length	.115
Radius, width proximal	.061
Radius, width distal (oblique)	.105
Carpal, length	.04
Carpal, width	.037
Metacarpal, length	.095
Metacarpal, width proximally	.045
Metacarpal, width medially	.018
Metacarpal, width distally	.034
Phalange (medial) length	.085
Phalange (medial) width proximally	.027
Phalange (distal) length	.059
Phalange (distal) width distally	.0082
Ramus mandibuli, depth in front of cotylus	.056
Cervical rib, length	.074

The total length of the anterior limb could not have been less than 0.90 m., which allows of five phalanges in the longest digit. There may have been more. That the digits were of unequal lengths is indicated by portions of two in the matrix accompanying the specimens, where the articulation of two phalanges falls opposite the shaft of one of the adjoining digits. The phalanges were separated by a short interval of cartilage. The size of this reptile was near that of *L. validus*, perhaps thirty-five to forty feet in length.

The affinities of this species, as incidentally pointed out, are to those Liodons which approach *Clidastes*. This is indicated by the many pterygoid teeth, the rudimental zygosphen articulation, the regular striæ of the bones, and the forms of the limb bones. In *Mosasaurus* the humerus is shorter and the phalanges are longer.

The specimens on which this species rests were discovered by Professor B. F. Mudge, State geologist of Kansas and professor of geology in the State Agricultural College of Kansas, on the north bank of the Smoky Hill River, thirty miles east of Fort Wallace, Kansas.

Numerous fragments of another larger individual were found by Professor Mudge near the same locality, which belong probably to the same species. Among them are a portion of the maxillary bone with bases of two teeth; the bases of the crowns where broken off are not compressed, slightly but oval. A radius is a flat bone, more dilated at one extremity than that of *Clidastes propython.*

	M.
Length radius	0.108
Width radius, narrower extremity	.064
Width radius, wider extremity	.08
Width radius, medially	.042

This species cannot be confounded with the *L. proriger*, Cope, and *L. congrops*, Cope, owing to its depressed vertebral centra; from *L. mitchillii*, De Kay, the equal and numerous pterygoid teeth separate it at once.

LIODON DYSPELOR, (COPE.)

(Proceed. Amer. Philos. Soc., Dec., 1870, p. 574.)

This species is represented by numerous vertebræ of the dorsal, lumbar, and caudal regions, and other remains, which will, at a future time, be more fully described than is possible at present. The vertebræ indicate the largest mosasauroid reptile known, and are remarkable for their form as well as size.

The centra of the dorsals are much depressed, quite as in *L. perlatus*, Cope, and *Mosasaurus brumbyi*, Gibbes. Their articular faces are of transverse lenticular form, the superior arch being a little more convex than the inferior, and obtusely emarginate for the floor of the neural canal. The superior outline is thus bilobed; the lobes rounded. The transverse curvature of the articular ball is quite regular, and not, as in *Mosasaurus maximus*, more steeply inclined at the external or lateral angles. A rather broad, smooth band separates the edge of the ball from the surfaces of the centrum adjacent. The latter are rather finely striate-ridged from the edge of this band. The inferior outline of the centrum is strongly concave, and with two venous foramina separated by a wide interval. The basis of a diapophysis on a lumbar is very broad, measuring more than half the length of the centrum. In general characters this lumbar resembles the dorsal, including the emargination for the neural canal, but is shorter in relation to its length.

The depressed form of the lumbar centra gives place gradually on the caudals to a more elevated pentagonal outline, which is still more reduced in width in more posterior regions. The hæmal arches are articulated and on the anterior caudals to slightly elevated bases; on the more posterior the bases are reduced in height, but more widely and deeply excavated. I have not seen the most distal caudals, and hence cannot determine whether their chevron bones articulate in pits, as is the case with those of *L. perlatus*, *L. proriger*, &c. On a caudal, where the depth of the centrum a little exceeds the transverse diameter, the diapophysis has become narrow and thick. The excavation for the neural canal is strongly marked on the more anterior caudal. The smooth border of the articular ball is here narrow, and the superficial nyæ are fine and confined to the anterior part of the centrum.

Measurements.

	M.
Transverse diameter ball post-dorsal	0.144
Vertical diameter	.097
Vertical diameter anterior caudal	.094
Transverse diameter anterior caudal	.107
Length centrum anterior caudal	.071
Transverse diameter neural canal	.0145
Transverse diameter basis diapophysis	.032
Transverse diameter basis diapophysis of a more distal caudal	.0278
Longitudinal diameter chevron articulation of a more distal caudal	.023
Length centrum	.068
Depth ball centrum	.093
Width ball centrum	.091
Length centrum of a lumbar	.106
Width of articular ball	.125

In instituting a comparison between this and other known mosasauridæ it will be necessary to consider species referred to *Mosasaurus*, as well as to liodon, from the fact that some of the former may really be liodons. The liodons, with compressed or round dorsal or lumbar vertebræ, may be dismissed from comparison. Of the depressed species *L. perlatus*, Cope, is known from specimens of one-third or less the size of the present one, which are further peculiar in having the diapophyses of the lumbars to stand on the anterior half only of the centrum. In *L. ictericus*, Cope, the centra are less depressed and the size still smaller than in the last.

Among *Mosasauri*, with depressed vertebral centra, it is to be noted that none present so great a degree of depression and lateral extension, except the *M. brumbyi* of Gibbes. They are all also much smaller. The *M. brumbyi* was founded by Dr. Gibbes on two lumbar vertebræ from the cretaceous of Alabama, which resemble those of the *M. dyspelor* in form and also in size. It is probably its nearest ally, and may be a liodon. Dr. Gibbes established the genus *Amphorosteus* for it, but without sufficient evidence to support it. The principal point of distinction between it and the *L. dyspelor*, which I observe, is the lack in the former of the strong emargination of the superior margin of the articular surface for the floor of the neural canal, which is so marked in the latter. I have only the figures of Gibbes to rely on for this particular, and it is scarcely probable that the artist would have overlooked it had it existed. Should the bounding prominences have been worn off, then the restored centrum would have had a notably greater vertical diameter than in the *L. dyspelor*, in the same portions of the vertebral column. As a second character I note that (relying, as before, on Gibbes's figures) the external angles of the depressed ball are not so extended laterally in *M. brumbyi.*

In size the vertebræ of the present animal exceed those of the *M. brumbyi.* The latter has been hitherto the largest known species of the order *Pythonomorpha*, exceeding two-fold in its measurements the *M. giganteus* of Belgium. So the present saurian is twice as great in dimensions as the New Jersey species I have called *M. maximus.* If, as is not entirely certain, the *M. missuriensis*, discovered by Webb, measures 75 feet in length, the *M. maximus* measured 80, and the *M. dyspelor* would not have been less than 100 feet in length. This would be the longest reptile known, and approaches very nearly the extreme of the mammalian growth, seen in the whales, though of course without their bulk. Such monsters may well excite our surprise, as well as our curiosity, in the inquiry as to their source of food supply, and what the character of cotemporary animals preserved in strata of the same geologic horizon.

The locality whence this reptile was procured is near Fort McRae, in New Mexico. It was discovered by Dr. W. B. Lyon, at that post, and by him sent to the Army Medical Museum at Washington, whose director placed it in the collection of the Smithsonian Institution. The attention to the paleontology of his neighborhood by Dr. Lyon will always be cause of satisfaction to students, and his name will be remembered with that of Turner, (discoverer of the *Elasmosaurus platyurus*, Cope,) Sternberg, and others.

The stratum is the yellow chalk of the upper cretaceous, which has yielded the *L. ictericus*, *L. proriger*, *Polycotylus*, &c., in Kansas, and of whose western extension into New Mexico the present species is evidence.

CLIDASTES, (COPE.)

(Proc. Acad. Nat. Sci., Phila., 1868, 233; Proc. Bost. Soc. Nat. Hist., 1869, 258; Transac. American Philos. Soc., 1869, 211.)

This genus is only known from the American cretaceous, though I have little doubt that it will be discovered in other parts of the world. It is distinguished from all other genera of the order by the presence of the zygosphenal articulation of the vertebræ. The humerus is of the most remarkable form, recalling slightly that of the mole among mammals, and indicates a most powerful swimming paddle or flipper in the position of the fore limb. The species do not average so large a size as those of the two preceding genera; the largest, *C. cineriarum*, did not exceed 35 feet in length. There are four species known, of which two occur in the cretaceous beds of Kansas. They are *C. cineriarum*, Cope, Kansas; *C. iguanavus*, Cope, New Jersey; *C. intermedius*, Leidy, Kansas and Alabama; and *C. propython*, Cope, Alabama.

CLIDASTES INTERMEDIUS, (LEIDY.)

(Proceed. Acad. Nat. Sci., January, 1870, p. 4.)

This species is established on several cervical and dorsal vertebræ, with portions of mandibular rami and other bones, from Alabama, discovered by Dr. Nott, of Mobile.

They indicate a species intermediate in size between the two others here described. The dorsal vertebræ are rather slender, more so than in *C. iguanavus*, and with articular faces with cup and ball remarkably oblique to the axis of the vertebra. The dense layer of the bone is thrown into numerous rugosities and ridges, as in *C. propython.*

What is more characteristic is the robust and even swollen form of the crowns of the teeth, and their slightly rugose enamel for the basal three-fourths the height. There are no facets. In the Kansas specimen there are twelve teeth in the dentary bone.

Rotten limestone upper cretaceous, of Pickens County, Alabama, and yellow chalk of Kansas.

CLIDASTES CINERIARUM, (COPE.)

(Proc. Amer. Philos. Soc., Dec., 1870, p. 583.)

The largest species of this genus, as indicated by the zygosphen articulation of the vertebræ.

The locality where it was found furnished also the *L. mudger*, but the specimens were taken from the gray bed, perhaps the same that produced the *Elasmosaurus platyurus*, Cope. They consist of vertebræ and a pterygoid tooth. There are two anterior dorsals, three lumbars, and one caudal. The articular faces of the dorsals are broad vertical ovals. They increase in width on the lumbars till on the last of these they assume the sub-pentagonal form characteristic of many species, and which is still more marked on the caudal. The centrum of the anterior dorsal is much compressed; inferiorly slightly concave longitudinally regularly and prominently convex transversely. Conversely, the rims of the cup and ball are strongly expanded, the latter with surrounding groove. The diapophyses of the lumbars are of considerable length, exceeding in this respect those of *Mosasaurus* we possess, where these parts are preserved. On the median of the lumbars the inferior surface of the centrum first becomes truncate or plane, and separated from that below the diapophyses, which become slightly concave. The expansion for the ball becomes more abrupt and striking on these vertebræ. The caudal is a little more compressed than the lumbars, and presents the character of coössified chevron bones. These are slender and longitudinally grooved.

A single pterygoid tooth was found in the matrix on one of the dorsals. The basis is short and much swollen; the crown curved, acute, a little compressed, and with an obuse cutting edge posteriorly.

Measurements.

Vertebræ, &c., from gray bed:

	M.
Anterior dorsal, length of centrum	0.0608
Anterior dorsal, depth of articular ball	.038
Anterior dorsal, width of articular ball	.038
Anterior dorsal, diameter behind diapophyses	.029
Anterior dorsal, depth of articular face for rib	.022
Lumbar, length of centrum	.06
Lumbar, depth of ball	.037
Lumbar, width	.039
Lumbar, length of remnant of diapophysis	.046
Lumbar No. 2, length of centrum	.055
Lumbar No. 2, width of zygosphen	.0182
Caudal, length of centrum	.041
Caudal, depth of cup	.04
Caudal, width	.04

	M.
Caudal, width of basis diapophysis	.0245
Caudal, width between chevron rami	.0115
Pterygoid tooth, height of crown	.0125
Pterygoid tooth, diameter of pedestal	.013

This species was found by Professor Mudge, near the locality of the *Liodon mudgei*, six miles south of Sheridan, Kansas.

It is only necessary to compare this species with *C. intermedius*, Leidy,* as the *C. iguanavus* and *C. propython* have depressed vertebral centra. Those of the first are round, of the present compressed. The *C. intermedius* also agrees with the two others in the obliquity of the articular faces to the transverse plane of the centrum; in the present species these planes are parallel. This species is also larger than the *C. iguanavus*, Cope; the *C. intermedius* is smaller.

There is another species from New Jersey to which it is more nearly allied, a vertebra of which I have described under the head of *Liodon lævis* (Trans. Amer. Philos. Soc., 1869, p. 205,) and figured l. c., Tab. V, Fig. 5, under the erroneous name of *Macrosaurus validus*. This probably does not belong to the *Liodon lævis*, which does not possess the zygosphen articulation, but is most likely allied to the present species, and a true *Clidastes*. When compared with a vertebra from the same position in the column, as determined by the position of the diapophyses, the articular faces are still more compressed, and the inferior surface of the centrum, instead of being regularly convex, forms a plane separated from lateral concavities by an obtuse angle. There is less expansion of the margins of the cup and ball. The size is also greater. I propose to distinguish this species as *Clidastes antivalidus*, Cope. It is from the darker stratum of the green sand, near Medford, New Jersey.

TELEOSTEI.

Physostomi.

SAURODONTIDÆ, (COPE.)

(Proceed. Amer. Philosoph. Soc., November, 1870, p. 529.)

The genus *Saurocephalus* of Harlan and its allies have been referred to the neighborhood of the Acanthopterygian family of the *Sphyrænidæ* by Professor Agassiz in his Poissons Fossiles, after having been regarded by Harlan and Hays as reptilian. This was an important step in the right expression of its affinities; but I take the present opportunity of making another progress in the true interpretation of its relations, favored as I am by the opportunity of examining new material not accessible to former authors. My conclusion, it will be observed, differs widely from that heretofore maintained.

Some years after Harlan's description of *Saurocephalus lanciformis* appeared, Dr. Hays described a second species under the name of *Saurodon leanus*. This I believe to represent a genus distinct from the former. A third genus more remote is characterized in the present article.

The characters of first importance which may be assigned to these genera are: Vertebræ short, numerous; their neural arches united with centrum by persistent suture. Tail vertebrated or heterocercal. Superior arch of the mouth formed by the short premaxillaries and long

* Proc. Acad. Nat. Sci., Philadelphia, 1870, p. 4.

maxillaries. Teeth one-rowed, with fangs received into alveoli more or less confluent at their openings. Anal or caudal radii with complex segmentation.

These characters are most of them entirely contradictory of any affinity to the *Sphyrænidæ*, those presented by the vertebræ indicating a nearer approach to *Amia*. The structure of the mouth is not that of any acanthopterygian fish, and with the complex segmentation of some of the radii approaches nearer such types as the *Characinidæ*. The form of the vertebral centra is utterly different from that of the *Sphyrænidæ;* in the *Saurodontidæ* they are short, little contracted medially, and deeply grooved on the sides; in the *Sphyrænidæ*, exceptional among teleosts in being elongate, much contracted, smooth, and grooveless!

The characters presented by the teeth and vertebræ of *Saurocephalus* remind one much of *Serrasalmo*, though the genus is no doubt in other respects widely removed from that group. On the characters above enumerated, I propose the family *Saurodontidæ*. Its precise position I am not prepared to determine at present, though I have little doubt that it is related to the *Salmonidæ*, and *clupeidæ*. With the remains of species of this group occur numerous scales, which may belong to the former. They are cycloid and without ganoine.

The three genera are distinguished by the form of their jaws and teeth: in *Saurocephalus* the crowns are shortened, much compressed, and with sharp edges; in *Saurodon* the crowns are elongate, subcylindric, and slightly curved near the apex. In *Ichthyodectes* the teeth are similar to those of *Saurodon*, but the margins of both jaws are without the large foramina so prominent in both the other genera. There appear to be some important differences also in the vertebræ, which will be mentioned below.

In the Transactions of the American Philosophical Society for 1856, Dr. Leidy treats *Saurocephalus* as a sphyrænoid fish, and regards *Saurodon* as a synonyme. He corrects the erroneous references of some European authors, showing the *Saurocephalus* of Dixon to be a Xiphias, and the *Saurodon* of Agassiz to be some other genus which he calls *Cimolichthys*, without characterizing it. This form is supposed to be established on palatine teeth, and if so, is well distinguished, as it will be seen below that *Saurocephalus* has no teeth on the palatine bones. He also refers two other species of supposed *Saurocephalus* of Agassiz to a new genus called *Protosphyræna*, without characters. This I think rests on mandibular teeth of true *Saurocephali*.

SAUROCEPHALUS, (HARLAN.)

(Journ. Acad. Nat. Sci., Phila., III, 337. ? *Xiphactinus*, Leidy, Proc. Ac. Nat. Sci., Phila., 1870, 12.)

SAUROCEPHALUS LANCIFORMIS, (HARLAN,) l. c.

(Med. and Phys. Researches, 362. Leidy, Trans. Amer. Philos. Soc., 1856, Tab. *Saurodon lanciformis*, Hays, Trans. Amer. Philos. Soc., 1830, 476.)

Established on a right superior maxillary bone from a locality near the Missouri River. It differs from that of the other species in having a very elongate superior suture with the premaxillary bone, and in the very short dental crowns, which are as wide as deep. The largest species; known from the jaw.

SAUROCEPHALUS PHLEBOTOMUS, (COPE.)

(Proceed. Amer. Philos. Soc., Nov., 1870, p. 530.)

Established on some vertebræ and portions of the cranium, the latter including the dentary, maxillary, part of the premaxillary, the palatine, and vomerine bones, compressed into a mass by pressure, the separate pieces preserving nearly their normal relations. From the latter the following characters may be derived:

Palatine bones toothless; teeth of both maxillary and dentary, with compressed crowns, which are longer than wide at base, and closely placed, those of the dentary twice as large as those of the maxillary. Maxillary bone proximally deep; dentary shallower, the maxillary with elongate suture with the premaxillary behind.

The teeth are equilateral, without intermarginal groove or barb, and with smooth enamel surface, or only minutely striate under the microscope. A series of larger foramina extends along the alveolar margin of the maxillary and dentary bones, one foramen to each tooth. The alveolæ are confluent as they approach this margin.

There are three vertebræ, which present two pairs of deep longitudinal grooves, viz: two on each side, two on the inferior, and two on the superior face of the bone; the last receives the basal articulation of the hæmapophyses. The centra are crushed; their measurements with those of the jaws are as follows:

	M.
Length centrum	.025
Long diameter (crushed)	.035
Short diameter (crushed)	.0175
Depth maxillary bone anteriorly	.031
Depth dentary bone anteriorly	.015
Length crown inferior tooth	.006
Number crown inferior tooth in .01m	3
Number crown superior tooth in .01m	4.5
Length crown superior tooth in .01m	.0046

The vertebræ are about as large as those of a fully grown "drum fish," *Pogonias*.

From the yellow chalk of the upper cretaceous of Kansas, found on the Solomon or Nepaholla River, Kansas, at a point 160 miles above its mouth, by Professor B. F. Mudge, professor of natural science in the State Agricultural College of Kansas.

I append a description of some caudal vertebræ of a species probably different from the *S. phlebotomus*. It is indicated by three consecutive caudal vertebræ which resemble those of *S. prognathus* and *S. thaumas*, but which differ also considerably from both; the several arches and spines are of very great width; in *S. thaumas* they are narrow, and in *S. prognathus* as wide, but here their width exceeds the depth and equals the length of the centrum. As in the other caudals, the lateral grooves are wanting and the inferior pair remain separated by a lamina. The neural suture is very distinct, and not two-angled as in *S. prognathus*, but with a median decurvature and rise anteriorly. The neural spines are twice as wide as deep and lie on each other. The third vertebra is shorter than the others and contracted distally; it is probably the penultimate of the series; neural canal minute. Surface striate-ridged.

Measurements.

	M.
Length of centrum anterior vertebra	0.021
Depth of centrum (at middle) anterior vertebra	.015
Width of neural arch at base of spine	.010
Depth of spine	.0072
Length of third vertebra	.0135
Width of neural arch	.014
Width of neural spine	.0176

From a point twenty miles east of Fort Wallace, Kansas. Professor Mudge's collection.

In this species the vertebræ in question are longer in proportion to their other dimensions than in those described, besides carrying wider neural arches and spines.

SAUROCEPHALUS PROGNATHUS, (COPE.)

(Proc. Amer. Philos. Soc., Nov., 1870.)

This species is represented by premaxillary and attached proximal portion of the maxillary bones of the right side, and by a large number of vertebræ and other bones. These portions were associated in the collections placed in my hands by Professor Mudge, and relate to each other in size, as do those of the preceding species and the *Ichthyodectes ctenodon.*

The premaxillary is characterized by its great depth as compared with its length, and by the shortness of its union with the maxillary. The palatine condyle of the maxillary reaches a point above the middle of the alveolar margin of the premaxillary. The latter contains alveolæ of seven teeth, the anterior of which only presents a perfect crown. This is still more elongate than the crown of the teeth of *S. phlebotomus.* It is compressed, equilateral, smooth, and acute. Its direction is even more obliquely forward than the anterior outline of the bone, which itself makes an angle of 50° with the alveolar border.

The vertebræ consist of cervicals, dorsals, and caudals, to the number of about sixty, most of which are supposed to have been derived from the same animal. The grooves are as in *S. phlebotomus*, there being two below, two on each side, and two above. The latter receives the bases of the neurapophyses, which are in many cases preserved. The inferior pair of grooves becomes more widely separated as we approach the cervical series, leaving an inferior plane, which is longitudinally striate-grooved. This plane widens till the grooves bounding it disappear. The inferior lateral groove becomes widened into a pit which some of the specimens show to have been occupied by a plug-like parapophysis, as in *Elops*, &c., or a rib-head of similar form. The neurapophysial articular grooves become pits anteriorly, and these only of all the grooves, remain on the anterior two vertebræ in the collection. Some of the posterior caudals preserve large portions of the neural arches and spines. They form an oblique zigzag suture with the body, consisting of two right angles, one projecting upward anteriorly, another downward behind. The neural spines are very wide and massive and in close contact antero-posteriorly; these probably support the caudal fin. They are deeply and elegantly grooved from the basis upward. The centra exhibit no lateral grooves.

An unsymmetrical fin ray accompanied these remains, and from its mineralization, color, size, and sculpture, probably belongs to them. The anterior margin is thinned, and with obtuse denticulations; the posterior truncate. The section is lenticular, with a deep rabbet on one side of the posterior edge; section at the base circular, apex lost. The sculpture consists of fine longitudinal raised striæ, which bifurcate and send numerous similar ridges to the teeth of the anterior margin. It is probably a spine of a pectoral fin. It is identical in form and sculpture with that described by Leidy as *Xiphactinus audax*, but differs in specific details.

	M.
Long diameter of spine	0.0245
Basal diameter of spine	.019
Length, to cervicals, (not distorted)	.033
Diameter of the anterior	.021
Length of a dorsal	.016
Length of a caudal	.014
Width of neural spine of caudal, at base	-012
Length of alveolar margin premaxillary	.022
Length of anterior margin premaxillary	.02
Depth from condyle of maxillary	.026
Length of crown premaxillary tooth	.0042
Diameter of crown premaxillary tooth	.002

A fragment of a large flat bone exhibits very delicate radiating grooves, which are marked by spaced impressed dots.

From the upper cretaceous of Kansas, six miles south of the town of Sheridan. Professor B. F. Mudge. This species was about two-thirds the size of the species last described.

SAUROCEPHALUS AUDAX, (LEIDY,) sp.

(*Xiphactinus audax*, Leidy. Proc. A. N. Sci., Phil., 1870, 12.)

Established on a pectoral spine, supposed by Leidy to be that of a siluroid. According to the description, it does not differ from that of *S. prognathus* in more than specific characters. Thus the anterior margin is weakly serrate in the latter, a feature not described by Leidy in the former. In *S. audax* the posterior portions of both sides are said to be grooved; in that part of the spine of *S. prognathus* preserved, one surface only exhibits the groove in question, one of whose edges is obliquely ridged, as in *S. audax*. From Kansas; museum Smithsonian.

SAUROCEPHALUS THAUMAS, (COPE.)

(Proc. Amer. Philos. Soc., Nov., 1870.)

This is larger than any of the species here described. It is represented by wholes or parts of from seventy to eighty vertebræ, with numerous neural and hæmal spines and fin radii, and perhaps some ribs. There are no teeth nor cranial fragments. The bulk of the vertebræ is double that of those of *S. phlebotomus*, and appropriate to an animal of the size of the *S. lanciformis*. It may be ultimately found to be identical with that species; but there is no evidence conclusive of such a view at present in my possession.

The vertebræ present the usual two inferior, two lateral, and two superior grooves—the last for the neural arch. There are no cervical vertebræ, for these characters show them all to be dorsals and caudals. The suture for the neurapophyses forms a regular angulate convexity projecting downward. The arch is not closed above anteriorly, and is expanded laterally, while the spine is directed very obliquely backward. The concavities of the articular extremities are equal in the dorsals; but in the caudals one surface is much more deeply concave than the other, one being funnel-shaped, and the other nearly plane in a few.

A number of consecutive vertebræ are preserved, which represent the posterior portion of the caudal series. One of these is, fortunately, the very extremity, and they demonstrate the tail to have been vertebrated or heterocercal, less extensively than in *Amia*. On the anterior series of three, the lateral grooves have disappeared from the centra; the neural canal is very small, and the spines are very massive and curved backwards, but much less than in the more posterior parts of the column; they are flattened, wider than deep, and in close contact with each other. The anterior of the three, on the other hand, presents a narrowed edge forward. The hæmapophyses are thin, and suturally united by a flat gomphosis. The terminal series embraces six vertebræ, which have a minute or obsolete neural canal, but hæmal canal distinct, but apparently interrupted. The hæmal arches are united to the centra by a rather smooth suture.

The general direction of these vertebræ forms a light upward curve. The hæmal spines are flat and laminar, and their margins in contact; they decrease in width and length to the end of the series. The neural spine lies obliquely backward, and has a narrowed anterior ridge, but stout shaft.

An anterior hæmal spine in place exhibits a subglobular base, like an articulation, and its shaft is wider than those posterior to it. The first hæmal spine is a sub-triangular flat bone, with neck and subglobular extremity, applies very well to a concavity between the anterior pair of pleurapophyses, but does not in that position preserve contact with the anterior margin of the second spine. One margin of the bone is thin and divergent; the other expanded laterally and straight. The latter gives off a transverse prominence like half a globular knob before reaching the extremity. Just within the latter are two large foramina, which are connected with the extremity by a groove on each side, which meets in a notch where the thin edge passes into the knob.

Both sides of the neural and hæmal spines are concealed in this species and in the *S. prognathus* by numerous parallel osseous rods, which are somewhat angulate in section. They lie along the centra of the anterior series of caudal vertebræ, but are not to be found on vertebræ of any other part of the column. Numerous loose and fragmentary rods of the same character accompany the loose and attached caudal vertebræ, and all of them, according to Professor Mudge, belong to the "posterior swimming organ" of this animal. There is also a collection of these rods from the anterior region of the body, which Professor Mudge thought occupied the position of an interior limb. They do not any of them present a segmentation such as would be exhibited by the cartilaginous radii of caudal and pectoral fins, and their nature might have remained doubtful but for the explanation furnished by the anterior compound ray or spine of the posterior, probably caudal fin. This ray, as in the case of the pectoral spine and first anal rays of some existing siluroid or loricariid fishes, is composed of a number of parallel rods closely united. These are in their distal portions remarkably and beautifully segmented, of which a very simple form has been figured by Kner, as existing in the pectoral spine of the siluroid genus, *Pangasius*. This segmentation becomes more obscure proximally, and finally disappears altogether, leaving the spine and rods homogeneous. This portion of them is quite identical with the rods found in the positions of fins already described, and I therefore regard these as fin radii of the attenuated form presented by cartilaginous rays of most fishes, but ossified sufficiently to destroy the segmentation. They are thus in the condition of the anterior rays of the dorsal fin of some of the large *Catostomidæ* where they are proximally homogeneous and bony, distally segmented and cartilaginous. This is an important character when found in pectoral and caudal fins, and such as I have not found described. It adds another feature to the definition of this group.

The segmentation above alluded to presents the following characters: The spine consists of four principal parallel rods, of which the external on each side thins, the one to an obtuse, the other to a thin edge. The more obtuse edge presents a groove on one side, which is occupied by a very slender rod, and a shallow rabbet along the flat edge is occupied by a slender flat rod. Of the four principal rods the two median are the most slender, and the flat marginal the widest. Of the two median, that next the last is the wider. The stout marginal, or probably anterior rod, is segmented en chevron, the angle directed forwards and lying near the free margin. The suture of the segments is entirely straight, except when returning it approaches the margin, where it suddenly turns to the margin at right angles to it. The next rod is segmented without chevron obliquely backward and inward; where it leaves and reaches the margins, it is at right angles to them, and the margin projects obtusely at those points. Between them the suture is very irregular and jagged, sending processes forward and backward. The segmentation of the next rod is similar, but more regularly serrate; distally it becomes as irregular as in the last. The transverse marginal termini of the sutures are serrate in both. The inner and widest rod presents a still more regularly serrate suture, with the truncate extremities; but, owing to the width of the rod, the near approximation of the sutures continues for a longer distance. When broken, the suture appears step-like.

This remarkably beautiful segmentation is paralleled remotely, as has been stated, by some siluroids, but much more nearly by the external caudal rays of elops. Much more like the recent type are the segmented rays of the carboniferous genus, *Edestus* of Leidy, regarded variously by authors as a jaw or a ray, but now generally regarded as a ray.

Measurements.

	M.
Length of fragment of (?) caudal spine	0.25
Width of fragment at proximal fracture	.06
Greatest thickness at proximal fracture	.013
Width of posterior rod at proximal fracture	.0245
Length of six distal caudal vertebræ	.10
Width of hæmal spine of second of series	.024
Vertical diameter of centrum, first series	.025
Length of neural spine and centrum of anterior caudal	.108
Transverse diameter of neural spine of anterior caudal at base	.0235
Antero-posterior diameter of four anterior caudal neural spines in contact	.069
Length of centrum of a dorsal	.04
Vertical diameter of a dorsal	.0615
Transverse diameter of a dorsal, (crushed)	.041

These remains were found in place by Professor B. F. Mudge. He states that their extent was eight feet. As they embrace no cervical vertebræ, nor portions of cranium, two feet are probably to be added, giving a total of near ten feet for the length of this fish. It was discovered at a point on the bank of the Solomon's or Nepaholla River, in Kansas, 160 miles from its point of junction with the Kansas River.

SAURODON, (HAYS.)

(Transac. Amer. Philos. Soc., 1830, 476.)

SAURODON LEANUS, (HAYS.)

(Loc. cit. Tab. xvi. Leidy, Trans. Am. Philos. Soc., 1856.)

From the cretaceous green sand of New Jersey.

ICHTHYODECTES, (COPE.)

(Proceed. Amer. Philos. Soc., November, 1870.)

In this genus the teeth are subcylindric and slender, without cutting edges. The inner margins of the maxillary and dentary bone exhibit no dental foramina, which are in *Saurocephalus* and *Saurodon* of large size.

ICHTHYODECTES CTENODON, (COPE.)

(Loc. cit.)

This species is established on one complete maxillary bone, and three-fourths of the other, a large part of the dentary bone, with the entire dental series; numerous portions of cranial bones, with thirteen vertebræ. These, according to Professor Mudge, were found together, and to all appearance belong to the same animal.

The dental characters differ from those of *Saurocephalus*, as above pointed out, and in this species more than in *S. leanus*. The crowns of the teeth are more exserted and slender. The inner face of the crown is more convex than the outer; but there is no angle separating the two aspects. The apex is moderately acute, and directed a little inward, owing to a slight convexity of the external face. Enamel smooth. The alveoli are very close together, and are probably only separated in their deeper portions. There are forty-two teeth and alveoli in the maxillary bone. The palatine condyle is low, and its anterior border falls opposite to the last tooth, or the indented surface which was occupied by the premaxillary bone. The more proximal part of the maxillary curves inward and backward behind the position of the premaxillary more than in *S. prognathus.* The maxillary is a rather thin and narrow bone, with a broad, obtuse and thinned extremity. Its superior margin is marked with one or more acute ridges, which look as though it had a contact with a large preorbital bone. Two fractured bones with an elongate reniform condyle on a wide peduncle, look like the articular extremity of an operculum, which view is confirmed by their application to some flat, coarsely-rugose bones which resemble parts of the latter.

The dentary bone is remarkable for its straightness and laminar character, and for the depth of the symphysis. The length of the latter is preserved, while posteriorly to it the lower margin of the dentary is broken away. The alveolar margin is slightly concave, and unites with the symphyseal at an angle of 65°. There are twenty-seven teeth and alveolæ, which grow a little larger to the posterior extremity of the series; anteriorly the alveoli are confluent externally, but posteriorly the septa are frequently complete, though thin. In neither this bone nor the maxillary are to be found the formina along the bases of the teeth, characteristic of *Saurocephalus* or *Saurodon leanus*, as pointed out by Harlan and Hays. The vertebræ form a series of 13.4 inches in length, embracing thirteen caudals. This is indicated by the close approximation of the inferior pits and inserted pleurapophyses, and absence of lateral grooves. There are important differences from what has been described as characteristic of *Saurocephalus*. The neural arches, whose bases only are preserved, are much lighter and narrower than in it, and its sutural union with the centrum is less distinct. Their bases issue from pits; but their anterior portions appear in some case at least to be coössified. They exhibit a longitudinal rib near one side. There are no heavy neural spines preserved. The sides of the centra are longitudinally rugose-striate; inferiorly they are rugose with exostoses.

Measurements.

	M.
Length of maxillary bone	0.158
Depth at condyle	.031
Depth at extremity	.022
Length of crown of a tooth	.0061
Diameter of crown at base	.0038
Length of alveolar border of dentary	.106
Depth of symphysis border of dentary	.047
Length of opecular condyle	.018
Length of centrum anterior caudal	.024
Width of centrum, (crushed)	.0278
Depth of centrum, (crushed)	.047

Specimens from six miles south of Sheridan, Kansas, on the north fork of Smoky Hill River, near its mouth.

GENERAL CONSIDERATIONS.

There have been described above remains of three species, which include jaws with teeth, and associated vertebræ. In two of these cases the jaws and teeth were found together; in the third they came in the same small box without special indication of locality; but the vertebræ are of precisely the same size, sculpture, mineralization, and color, as a large series whose locality is exactly known, to which they probably belong. Moreover, the jaws and vertebræ bear the same relation of size to each other in all three series. These facts render it highly probable that the remains are in each case rightly referred to the same animal. That no mixture has occurred is also probable from the fact that the large and small series (*Ichthyodectes* and *S. prognathus*) came from the same locality, (Sheridan,) while the species of intermediate size was discovered one hundred and sixty miles from the mouth of the Solomon River, a long distance off. The pectoral spine, accompanying and belonging to the S. prognathus, I have shown to be the same as the *Xiphactinus* of Leidy, but probably not of the species *X. audax*.

The fourth series described above as *S. thaumas* exhibits precisely the vertebral characters of the two other species of *Saurocephalus* and I cannot resist the evidence that it belongs to that genus or the same family. Its remains pertain to one animal, as asserted by Professor Mudge, and their color and condition, coated with a chalky deposit of a ferruginous yellow color, lend great probability to the statement, to say nothing of more important reasons. No remains of pectoral spine are preserved; but instead, the remarkable segmented ray described. This comes from the posterior region of the vertebral column, and consists, I believe, of the adjacent rays or compound ray forming the margin of the caudal fin. This finds support in the analogous structures already mentioned as occurring in *Elops*, and the extinct genus *Prymnetes*,* *Siluroids*, &c., and the resemblance of the pectoral spine to the same weapon of the latter group adds to the probability of the correctness of this conclusion.

These remarks are made because Professor Agassiz, in the Poissons Fossiles, has referred several spines to the *Cestraciont* genus *Ptychodus*, which are very similar in character to that described above as the anal or caudal support of *Saurocephalus thaumas*. These were derived from the upper cretaceous chalk of Kent, England, where *Ptychodus* teeth also occur. The *Saurocephalus* teeth, described by Professor Agassiz in the same work, were, however, derived from the same chalk and the same locality, and, from what has preceded, I believe the segmented spines should be referred to the latter genus rather than to *Ptychodus*. This is the more probable, in view of the fact that Professor Mudge did not procure a single *Ptychodus* tooth during his exploration.

APSOPELIX, (Cope.)

Established on the remains of a fish preserved on a block of clay. It presents its ventral aspect, and displays pectoral, ventral and anal fins, with the series of interneural spines to which the dorsal radii were articulated.

The scales are large and cycloid. They do not present a trace of radii, but are marked with fine and close concentric grooves. These assume a vertical direction on the exposed surface, and are there more irregular; the more marginal ones terminating above and below. But few and central grooves are truly circular. No abdominal carina.

The two pelvic bones are together truncate heart-shaped, the acuminate apex presented forward. Their posterior portion is a strong transverse rib; anteriorly each is a thin plate, with thickened outer edge, uniting with its fellow on the median line. The median portion is so thin as to be readily broken away. The ventral fins are short and wide, with numerous rays. The coracoid bone is a broad lamina, and the pectoral fin evidently had the support of rod-like humeral bones of no great length, after the type of most *Physostomous* fishes, but their form cannot be made out. Pectorals not elongate. The anal fin originates but a short distance behind the ventrals, and was not armed with an anterior spine; its length cannot be made out. Immediately above it a dorsal fin, with slender rays, is represented by the bases of these rays. From above the ventrals to above the distal portion of the pectorals a line of projecting points appears in the specimen, which I am disposed to ascribe to the articular portions of the interneural spines and attached fin rays of a first dorsal, but of this I cannot be entirely sure.

The vertebræ are longer than deep, and present the two deep lateral grooves frequently seen. The number in the cervico-abdominal series is twenty-six. The ribs are delicate, and supernumerary ribs are present.

In comparing this genus with forms already known, points of distinction from all of them may be detected. Thus, the lack of pectoral spine will distinguish it from the known genera of *Saurodontidæ* at least. The character of the dorsal fin distinguishes it from *Characinidæ*, *Salmonidæ*, &c., which, with the scales, point toward *Clupeidæ* and *Elopidæ*. From these the form of the pelvic bones distinguishes it.

The ends of both muzzle and caudal region are destroyed. The latter

* Copé Proc. Am. Phil. Soc., March, 1871.

evidently contracts from the anal fin, and was not probably very elongate, but more as in *Elops* or *Saurus*.

APSOPELIX SAURIFORMIS, (COPE.)

Scales large, ten longitudinal series to be counted across the obliquely depressed body. No lateral line visible. About seventeen transverse series between pectorals and ventrals. Ventral broad, when laid backward nearly reaching anal, but far behind the pectoral; anal probably rather short, but this is not entirely certain. (Radii, D. ?—12, P. 16, V. 12.)

	M.
Length from basis P. I., to V. 12	0.083
Length from basis P. I., to A. I	.0985
Length of ventral fin	.0178
Width of ventral fin, distally	.013
Length of basis D. 2	.0168
Width of body	.047
Width of pelvic bones together	.016
Length of pelvic bones together	.016

The size of this species is about that of a one-pound brook trout.

From the bed No. 2 of the cretaceous of Meek and Hayden. Found in digging a well at Bunker Hill Station on the Pacific Railroad of Kansas.

SPHYRÆNIDÆ.

SPHYRÆNA CARINATA, (COPE.)

(Proc. Acad. Nat. Sci., Phila., 1868, 92; Proc. Amer. Philos. Soc., 1869, 241.)

Founded on a shed example of one of the long teeth, taken from the matrix attached to the dorsal vertebræ of the *Elasmosaurus platyurus*. The tooth is more elongate in outline than that of the *S. speciosa*, Leidy, *i. e.*, more than twice as long as wide at the base. The anterior margin is the more oblique, and its smooth face is margined by a faint line posteriorly, and is continued to the extremity. The convex inner face of the tooth behind is sculptured with five deep grooves, which are separated by acute ridges, which do not extend over more than half the length of the tooth. Length three lines.

From the upper cretaceous of the neighborhood of Fort Wallace, Kansas.

Enchodus, sp.

A premaxillary tooth of rather small size for the genus. The length about one inch from the matrix attached to the under side of the dorsal vertebræ of *Elasmosaurus platyurus*. It has two carinæ separating very unequal facets. Section of base subround. The specimen is imperfect. Near Fort Wallace.

VII.—ON THE FISHES OF THE TERTIARY SHALES OF GREEN RIVER, WYOMING TERRITORY.

BY PROFESSOR EDWARD D. COPE.

Physoclysti.

ASINEOPS, (COPE.)

(Proc. Amer. Phil. Soc., 1870, p. 380.)

Branchiostegal radii, seven; ventral radii, I. 6–7. Opercular and other cranial bones unarmed; scales cycloid. Spinous and cartilaginous dorsal fins continuous; caudal rounded; anal with two spines. Lateral line distinct. Operculum with regularly convex posterior border. Teeth coarsely villiform, without canines. Both spinous and soft portions of dorsal and anal fins moderately scaly.

This well-marked genus is established on the remains of fifteen individuals, in various states of preservation, so that the characters undistinguishable in one, can be discovered in another. Thus the lateral line is preserved in one only, and the teeth in another. In none can I be entirely sure that I see the vomer.

The scales are preserved in many specimens, and I cannot find a ctenoid margin in any, nor any radiating sculpture, but delicate concentric ridges continued around the central point proximally, distally forming parabolic curves, the less median not completed but interrupted by the margin of the scale. Near the margin all the ridges become gently zigzagged.

There is no depression between the two portions of the dorsal fin, though the cartilaginous portion is the more elevated. Laid backward, the latter is in line with the extremity of the anal, and both it and the anal extend beyond the basis of the caudal.

The affinities of this genus are rather obscure, but are in some degree related to that aberrant family of Physoclysti, the *Aphredodiridæ*. This is indicated by the increased number of ventral radii, the slender separated pubes, and the reduced number of interneural spines. The *Aphredodiridæ* betray a physostomous tendency in the same characters, with still greater reduction of the spinous, dorsal, and anal fins, though its ctenoid scales and spinous orbital and preopercular bones are of physoclyst significance. In *Asineops* the scales are cycloid and the cranial bones unarmed. The ventral fins occupy nearly the same position as in the extinct genus *Erismatopterus*, Cope, which accompanies it, and which is nearly allied to, if not one of the *Cyprinodontidæ*. There is at least in these genera another illustration of the approximation of forms, now very distinct, in past periods. The pubes are, however, supported by the clavicles in *Asineops*, by the post-clavicles in *Erismatopterus*, though the latter bones are very long in *Asineops* also. *Asineops* and will thus constitute a family, *Asineopidæ* differing from the *Aphredodiridæ* in the simple pubes. I suspect that the genus *Pygæus* of Agassiz will be found also to belong to it, though no such increased number of ventral radii is assigned to it in the Poissons Fossiles. Some of its species may even be found to belong to *Asineops*. Nine are described by Professor Agassiz, all from Monte Bolca, in Italy, from an upper eocene stratum. The presence of so near an ally as *Asineops* in the Green River beds suggests an approximate identity of age.

ASINEOPS SQUAMIFRONS, (COPE;) l. c., p. 381.

General form is suboblong, the greatest depth just behind the head, and contained two and a half times in the length, exclusive of caudal fin. Radii D. VIII, 14; A. II, 9; C. 14; V. I, 7; P. ?11 ?13. Scales 5—?30—10, vertical line counted a little behind the ventral fins. The line of the extremities of the second dorsal and anal fins marks the basal third of the caudal fin. The dorsal spines are subcylindric, slightly curved, and of nearly equal length; the length equals the depth of the body at the middle of the second dorsal fin.

The external series of villiform teeth are stout of their kind, conic, and a little incurved. I cannot see the pharyngeal bones or teeth.

The number of vertebræ which extend between the caudal fin and the superior margin of the operculum, where one or more are concealed, is twenty-five, of which fifteen are of the caudal portion; (in two I can only count fourteen.)

The mouth is directed obliquely upwards and is rather large; the mandible, when closed, does not project beyond the premaxillary border. The maxillary, where preserved, is narrow distally, and does not project beyond the posterior line of the orbit. The latter is rather small, and though not well defined in any specimen, is not more than one-eighth the length of the head, and 1.5 to 1.75 times inside of muzzle. The margins of all the opercular bones are entire and smooth. The interoperculum is narrow, and lies obliquely upward, narrowing the operculum. The greatest width of the latter is more than two-thirds its depth. The pelvic supports of the ventral fins are simple, slender, and in contact anteriorly, their length about half that of the fin. The pectorals are not elongate.

The scales extend over the top of the head to, or beyond, the orbits. They also extend along the ramus of the under jaw. Those of the fins are quite small; they extend to a considerable distance on the unpaired, and on the caudal fin.

	M.
Total length of the largest specimen	0.19
Do. No. 2, smaller example (with caudal)	.12
Length of head of do.	.044
Depth of do. posteriorly about	.036
Length of base of spinous dorsal	.0265
Length of posterior spinous ray	.017
Length of operculum	.0125
Length of maxillary bone about	.0145
Depth No. 3, at base first dorsal	.045
Depth No. 3 at base anal, first ray	.0325
Length of basis anal=basis caudal	.0162
Length of caudal fin	.034

Tertiary strata of Green River, Wyoming; Dr. F. V. Hayden, Coll. Mus. Smithsonian.

ASINEOPS VIRIDENSIS, (COPE;) sp. nov.

This species is represented by an incomplete specimen, which lacks the pectoral region and the end of the muzzle. It indicates its distinctness from *A. squamifrons* in the increased number of anal radii. The ray formula is, D. IX, 14; A. II, 12. There is, therefore, one dorsal spine more than in *A. squamifrons*, though a single specimen, apparently of the latter, has the same number. Vertebræ 25, of which 17 or 18 extend from the vertebra which supports the last dorsal spine. The scales are of about the same size as those of the *A. squamifrons.* Dorsal region scarcely convex, (in the specimen concave through slight distortion.)

	M.
Length of vertebral column to operculum	0.07
Depth at last anal ray	.019
Length of last dorsal spine	.017

Another specimen lacks the head and caudal fin, but displays characters at variance with those of *Asineops squamisfrons* as above noted. The interneural bones of the anal spines are fasciculate, the median longer than those in front and behind.

The ventral outline is convex, and the general form shortened. Radii A. ? II, 14; D. ? 12–13. There are only 13 vertebræ behind the last anal spine.

	M.
Length of vertebral column from vertebra supporting last A. spine	0.033
Depth at second soft A. ray	.027

From the Green River shales; from the collection of Lucius E. Ricksecker.

ERISMATOPTERUS, (COPE;) genus nov.

Dorsal and anal fins with two strong supporting spines in front; no other interhæmal spines than those supporting them. Dorsal fin above the anterior median or posterior abdominal region. Ventrals originating in front of or opposite to the origin of the dorsal. Pubes sending a limb upward, which is in contact with the inferior post-clavicle. Teeth minute or ? wanting. Caudal fin bifurcate.

I originally referred a species of this genus to the *Cyprinodontidæ* and provisionally to the genus *Cyprinodon.* The species may belong to that family, as the characters are generally similar. The arc of the mouth is formed by the premaxillary bone, and the ventral fins have a rather anterior position, and the caudal is furcate; the scales are cycloid. The strength of the spinous fin radii and supporting interhæmal spines attracted my attention, and on careful examination I observe other approximations to the type of *Asineops* and the *Aphredodiridæ.* The inferior post-clavicle is very long and styliform, as in the latter genus, and the pubic bones are slender and directed upward so as to reach the post-clavicles. In one specimen there appears to be an anteriorly directed pubic limb, but this does not exist in other specimens. The pubes do not reach the clavicles as in true *Physoclysti.* As the genus is thus different from *Cyprinodon, Fundulus,* &c., I name it as above.

ERISMATOPTERUS RICKSECKERI, (COPE;) sp. nov.

Length, three to four inches; head, large. Vertebræ, D. 13, C. 16=29, ten between the interneural bone supporting the first dorsal ray, and the first interhæmal supporting the first anal ray. There are only seven in this position in *E. levatus.* Anterior dorsal ray anterior to the point half way between end of muzzle and end of vertebral column. Branchiostegal radii, five distinguishable. Head stout, mouth terminal, orbit equal length of muzzle; maxillary bone reaching line of middle of orbit. Scales small with numerous concentric and no radiating grooves. Fin radii D. VII, 8, (last split;) C. 8—19—8; A. II, 9; V. 7; P. 15.

	M.
Total length No. 1	0.0743
Cranium to supra-clavicle	.018
Length to base D. I	.029
Length to end vertebral column	.06
Length of A. II	.008
Length of cranium No. 2	.0175
Length to preoperculum	.012
Length to D. I	.0275
Length to A. I	.043

Five more or less complete specimens of this fish were obtained by Lucius E. Ricksecker from the Green River shales, and I dedicate it to him in recognition of his interesting discoveries in this department.

Its difference from *E. levatus* is seen in the more anterior position of the dorsal fin, more numerous vertebræ, &c.

ERISMATOPTERUS LEVATUS, (COPE.)

(*Cyprinodon levatus,* Cope; Proceed. Amer. Philos. Soc., 1870, p. 382.)

Anterior margin anal fin commencing a little behind opposite the posterior margin of the dorsal. Vertebræ 11—14—5, seven between the interneural and interhæmal bones of the dorsal and anal fins. Radii D. 8; A. II, 8; V. 8. Caudal fin deeply furcate; first anal ray strong. General form elongate, the greatest depth contained three times in the length between the scapular arch and the basis of the caudal fin. Scales preserved, small; seven longitudinal series above, and seven below the vertebral column, probably two rows concealed by it. The caudal peduncle is but little contracted. Length from scapular arch to extremity of caudal, M. .0335; depth at origin dorsal fin, M. .008.

Total length No. 2	0.055
Length of cranium	.013
Length to basis D. I	.0232
Length to basis A. I	.033
Length to basis V. I	.0205
Length to basis caudal	.0466
Depth at D. I	.01
Depth of caudal peduncle	.0058

There are many individuals on the slabs of slate, some of them perfectly preserved. Many of these slabs represent that portion of the stratum which is highly carbonaceous, portions of it thrown into the fire burning freely. Dr. Hayden, who has brought numerous specimens from this locality, informs me that the laminæ exhibit great numbers of these little fishes. No doubt the carbonaceous character of the shales is due to the decomposition of their bodies. The nature of the deposit and mode of preservation remind one strongly of the *Cyprinodon meyeri* of Agassiz, from the neighborhood of Frankfort a. M. That species differs specifically from this one in presenting 18 anal radii.

Some of the specimens above described were obtained, and preserved for scientific study, by L. E. Ricksecker.

Physostomi.

CLUPEA, (LINN.)

CLUPEA HUMILIS, (LEIDY.)

(Proceedings of Academy of Natural Sciences, 1856, 256.)

Vertebræ, 34. Depth, $2\frac{1}{2}$ to $2\frac{2}{3}$ lines in length, exclusive of caudal fin, ($2\frac{1}{4}$ times, Leidy.) Scales large; l. transverse 11–12. A very abundant species in the shales, distinguished by its corpulent form.

CLUPEA PUSILLA, (COPE.)

(Proceed. Amer. Philos. Soc., 1870, p. 382.)

Greatest depth contained four times in the total length, or 3.5 times to basis of caudal fin. Length of head 3.2 to basis caudal. This measurement may require revision, as the end of the muzzle is slightly injured. Orbit large, contained twice in length, and about over the origins of the ventrals. D. II, 11; V. 7. Pectoral extending half way to ventrals. Vertebræ, 29–30; dorsals, 19–20. Ventral keeled ribs, 18. Anal fin lost. Caudal peduncle slender; caudal fin deeply furcate. Length, M. 044; greatest depth, M. .011.

A second specimen exhibits the character of the species more distinctly in some respects. There are 30 vertebræ, of which 13–14 are caudal. The general shape is regularly fusiform, and the head rather acuminate.

	M.
Total length	0.054
Length to preopercular edge	.01
Length to opercular edge	.013
Length to posterior margin dorsal	.0255
Length to anterior margin anal	.034
Length to base caudal	.044
Depth at occiput	.011
Depth at middle of dorsal	.0115
Depth at caudal peduncle	.0046

This species is therefore much more lanceolate in outline than *C. humilis*, and has fewer vertebræ. It is half the size, and not nearly so abundant.

OSTEOGLOSSUM, C. V.

The discovery of this genus, or a close ally, in the Green River shales, by Lucius Ricksecker, is one of the most interesting in the history of this department of paleontology which has been lately made.

Osteoglossum has hitherto been known only in a recent state, and with a range of distribution quite unparalleled among teleostean fishes. Thus one species—*O. bicirrhosum*, Vand., occurred in Brazil; *O. formosum*, Schl. Müll., in Borneo, &c., and *O. leichardtii*, Gthr., in New Zealand; all in the southern hemisphere or near the equator. Two other genera, *Vastres* and *Heterotis*, have been associated with it, and these belong to the same hemisphere, or to those faunae which characterize it, in their extensions north of the equator. It is therefore interesting to note that the first representative of the type found in any of the northern faunal regions belongs to an age apparently eocene.

The specimen representing the type species is not sufficiently perfect to justify a final reference, but the squamation is much more that of this genus than of either of the others above mentioned. It belongs in any case to the same family group. The structure of the scales is sufficient to determine this point. The whole of the scale is composed between the inferior and superior surface layers, of sub-hexagonal or diamond-shaped cells, which are arranged in spirals tending to the center. Their contents are more thoroughly calcified on the exposed than in the concealed portion of the scale. No radial grooves. Tube of the lateral line issuing by a round pore.

OSTEOGLOSSUM ENCAUSTUM, (COPE;) sp. nov.

Represented by a portion of the side of a large individual, including the series of scales bearing the lateral line, and three series above and three below it, more or less perfectly preserved. The longitudinal extent of the fragment includes seventeen transverse series. These scales are of large size, the included portions are smooth to the naked eye, but rugose under the microscope, and with but few and faint traces of concentric lines. Exposed portions with entire margin, bearing a large lenticular rugose surface. This rugosity consists of elevated portions of an enamel-like material, between small pits and grooves. The septa between the cells are distinctly visible on the smooth part of the scale; on the rugose surface they are represented by grooves. The cells are in curved series, which extend to the center of growth, growing smaller as they converge. The rugose part of the exposed surface diminishes in relative extent towards the anterior part of the body. The tubes of the lateral line are in this species concealed beneath the external layer of the scale. The opening is nearer the margin than the center of the scale, is round, and is frequently accompanied by a smaller one above and in front of it.

	Inches.
Length of fifteen consecutive scales	0.23
Depth of six longitudinal series scales	.127
Vertical diameter of a scale	.035
Transverse diameter of a scale	.025
Diameter of a submarginal scale cell	.003
Width of rugose area of scale	.011

As compared with the species of the genus whose scales have been figured, the present offers clear distinction. In *O. bicirrhosum*, figured in Agassiz and Spix Brazilian fishes, Tab. XXV, the scales have distinct concentric grooves, and the rugosity consists of a few points or projections. In *O. formosum*, figured in Solomon Müller's travels in Borneo, &c., the rugosity is uniform on the exposed surface and very minute, and there are no concentric grooves; the cells are smaller. In *Vastres* the exposed surfaces are still more rugose—in large examples, quite honeycombed.

The specimens represent an individual of three or four feet in length, discovered at the fish-slate cut on the Green River, on the line of the Union Pacific Railroad, by Lucius E. Ricksecker, civil engineer.

GENERAL OBSERVATIONS.

The laminated rock from which the above species were obtained is similar in general appearance to the clay beds of Mount Lebanon and Mount Bolca. The first indication of the existence of this deposit was brought by Dr. Jno. Evans, who obtained from it a clupeoid, which was described by Dr. Leidy as *Clupea humilis*, (Proc. Acad. Nat. Sci., Phila., 1856, p. 256.) One of the blocks contains the remains of two small shoals of the fry, probably of *C. humilis*, which were caught suddenly by a slide or fall of calcareous mud, and entombed for the observation of future students. They must have been taken unawares, since they lie with their heads all in one direction as they swam in close bodies, One or two may have had a moment's warning of the catastrophe, as they have turned a little aside, but they are the exceptions. The fry are from one-half to three-quarters of an inch long and upward.

True herring, or those with teeth, are chiefly marine, but they run into fresh waters and deposit their spawn in the spring of the year, and then return to salt waters. The young run down to the sea in autumn and remain there till old enough to spawn. The size of the fry of the Rocky Mountain herring indicates that they had not long left the spawning ground, while the abundance of adults suggests they were not far from salt water, their native element. To believe, then, that the locality from which these specimens were taken was neither far from fresh, nor far from salt waters, is reasonable; and this points to a tide, or brackish inlet or river. The species of *Cyprinodontidæ* inhabit also tide and brackish waters. Most of the species of the family, as well as of the genus, are inhabitants of fresh water; but they generally, especially the cyprinodons proper, prefer still and muddy localities, and often occur in water really salt. This habitat distinguishes them especially from *Cyprinidæ* (minnows and suckers) and pike. Lastly, the known species of *Osteoglossum* inhabit fresh waters.

The material which composes the shales indicates quiet water, and not such as is usually selected by herring for spawning in; while the abundance of adult clupeas indicate the proximity of salt water.

This is far from a satisfactory demonstration of the nature of the water which deposited this mass of shales, but is the best that can be obtained with such a meager representation of species.

As to geological age the indications are rather more satisfactory. The genus *Clupea* ranges from the upper eocene upward, being abundant in the slates of Lebanon and Monte Bolca, while *Cyprinodon* has been found in neither, but first appears in the middle or lower miocene in Europe. The *Asineops* resemble very closely, and I believe essentially, the Pygæus of Agassiz of eocene age, from Monte Bolca. The peculiarities presented by the genus found by Dr. Hayden are of such small significance as to lead me to doubt the beds in question being of later than eocene age, though the evidence rests chiefly on this single, new, and peculiar genus.

The position of these fishes, seven thousand feet above the level of the sea, furnishes another illustration of the extent of elevations of regions once connected with the ocean, and the comparatively late period of geologic time at which, in this case, this elevation took place.

VIII.—RECENT REPTILES AND FISHES.

REPORT ON THE REPTILES AND FISHES OBTAINED BY THE NATURALISTS OF THE EXPEDITION.

BY E. D. COPE, A. M.

Twenty-two species of fishes and eight of reptiles are embraced in this collection. Among these the principal interest attaches to the fish-fauna of the Colorado River of the West, and its system. Isolated as are its waters from the systems of the Columbia on the north, of the Platte on the east, of the Rio Grande on the southeast, and of the Pacific Coast streams on the west, an inquiry into the character of its fauna becomes desirable. This has been entered on with much success by our distinguished ichthyologists, Messrs. Baird and Girard, who have determined the existence of at least one type as peculiar to it; I allude to the genus or group *Gila*. They have also shown that nearly, if not all, of the species belonging to it differ from those of the other basins—a conclusion which the collections of Dr. Hayden confirm. The number of species from the heads of the Colorado included in the present collection numbers 13, none of which have been found in other waters, if we include in this basin those which empty into the lakes of Utah—and of which five are new to science.

Beyond the possession of peculiar species and one peculiar genus this river basin does not differ from others except in what it lacks. This want of forms may be owing to the poverty of our collections, or to their real absence. It is enough to mention *Siluroids*, *Hyodon*, *Esox*, *Lepidosteus*, *Amia*, and *Physoclysti*, in general, to express the imperfection of our knowledge and the probability that, when examined, an interesting faunal combination may be discovered. Not the least interesting fact is the occurrence of a *Coregonus* in the Green River and other upper waters of the basin.

The other fishes obtained by Dr. Hayden are from the upper tributaries of the Platte. As pertaining to the same great Missouri drainage area, a few species from the neighborhood of St. Joseph, Northwestern Missouri, are added. These were submitted to me by Dr. William Stimpson, secretary of the Chicago Academy of Sciences.

REPTILIA.

CAUDISONA CONFLUENTA, Say, (*Crotalus.*)—Utah, Colorado, Wyoming, &c.

HETERODON NASICUS, Baird and Girard.—Head-waters of the Platte.

EUTÆNIA PARETALIS, Say, (*Tropidonotus*, Halb.)—Head-waters of the Platte.

EUTÆNIA VAGRANS, Baird and Girard.—Utah, Wyoming, and Colorado.

HOLBROOKIA MACULATA, Baird and Girard.—Head-waters of the Platte.

PHRYNOSOMA DOUGLASSII, Bell.—Head-waters of the Platte.

BATRACHIA.

RANA HALECINA, Bosc.—Common along all the streams.

TELEOSTEI.

Cottidæ.

URANIDEA PUNCTULATA, Gill, (*Potamocottus*;) Proc. Boston Soc. N. H., 1861, 40.—Head-waters of Green River.

Salmonidæ.

SALMO (Salar) VIRGINALIS, Girard; United States Pacific Railroad Survey, Vol. X, p. 320, Pl. LXIII, figs. 1–4.—This species is well figured by Girard as above. An error occurs in the enumeration of rays, where the branchiostegals are said to number 9–9; they are, I find in three specimens, 11–11. The species is distinguished from *S. iridea*, Girard, by its more slender form and fewer anal and dorsal radii. When the specimens were first received they exhibited short, broad, longitudinal red bars along the lateral line.

Seven specimens, two from Henry's Fork Green River, and two from near Fort Bridger.

SALMO (SALAR) STOMIAS, (COPE;) sp. nov.

Salmo (*Trutta*) *lewisii*, Cope. Proceed. Acad. Nat. Sci., Phila., 1865; nec. Girardii.

General form short and stout, the head large and wide, with wide mandible and mouth. The length of the head enters four times to near the emargination of the caudal fin, and the depth at the first dorsal ray four times in the length to the end of the basal scales of the caudal. The base of the first dorsal ray is nearly equidistant between the end of the muzzle and base of caudal fin, or, more exactly, rather nearer to the base of the marginal caudal ray than to the muzzle. Radii, B. 10, D. II. 12, A. II. 10, V. 9. The end of the maxillary extends half the eyes diameter behind the margin of the eye. Interorbital width 3.5 times in length of head; eye, 4.6 times in the same, and equal to the length of the muzzle. Symphysis of mandible equal to or shorter than muzzle; gape wide. Forty-two longitudinal scales above the laternal line. Maxillary bone of nearly uniform width.

There are indistinct brown blotches on the sides, and numerous black spots on the posterior dorsal region, the entire caudal peduncle and the two dorsal and caudal fins; anal unspotted; spots few in front of dorsal.

	M.
Total length of smaller specimen	0.227
Length of head	.0515
Length to ventrals	.106
Length to anal	.15
Width lower jaw, at orbits	.0168

This species is an ally of the *S. lewisii*, *S. virginalis*, and *S. iridea*. From the last of these the fewer anal radii distinguish it. From *S. virginalis* the stouter form, wider head with shorter muzzle, and one less branchiostegal ray, separate it. Thus in that species the head enters the length to the end of the caudal scales four times, and the depth 4.5 times. The dorsal is considerably nearer the end of the muzzle than the basis of the caudal. The eyes and interorbital widths are less. The *S. lewisii*, like *S. stomias*, from Mississippi waters, is more like *S. virginalis* in all the respects mentioned, according to both the description and figures of Girard, but adds the peculiarity of only 10 branchiostegals instead of 11.

Two specimens from the Platte River, from near Fort Riley, Kansas. Discovered by William A. Hammond, M. D.

COREGONUS WILLIAMSONII, Girard; United States Pacific Railroad Reports, X, p. 326, Pl. LXVI.—The Rocky Mountain white fish.

With the *Salmo virginalis*, probably from near Fort Bridger, from the head-waters of the Green River or Western Colorado.

Catostomidæ.

I have proposed to adopt as valid (Proc. Amer. Philos. Soc., 1870, 480) seven genera of this family. I would now add an eighth, which embraces species which combine with the characters of *Catostomus* proper, a complete union of the parietal bones, which obliterates the fontanelle so universal among the suckers. The only other exception is seen in *Cycleptus*, Raf., as I have already mentioned. In all the members of the family where I have examined it, this fontanelle is quite open and of no doubtful proportions, and nowhere reduced to the slit often seen in the *Siluridæ*. In searching for the characters of Girard's so-called genera Minomus and Acomus, I find that the type of the former, *M. insignis*, B. G., presents the character above mentioned. I therefore adopt his name for the new genus, and add two new species, *M. delphinus* and *M. bardus*. Whether his two other species, *M. plebeius* and *M. clarkii*, belong to it is uncertain as yet, but they have the same physiognomy.

CATOSTOMUS, (LES.)

Several species of this genus were procured by Dr. Hayden. For their fuller elucidation the following table, embracing also those of Minomus, is appended.

I. Scales of the posterior part of the body materially larger than those of the anterior. a Anterior dorsal ray nearly equidistant between end of muzzle and base of caudal fin. Head five and a half times in length to end of caudal; muzzle projecting, upper lip pendent, very short, with two rows tubercles; smooth margins narrow; scales l. tr. 28; eye $\frac{1}{6}$–$\frac{1}{7}$ head; V. 10.	*C. griseum.*
As the last, but the lips much larger; upper with three rows tubercles, and both with wide smooth margin; eye, 5.5 in head, V. 9; isthmus wider.	*C. discobolus.*
II. Scales of body subequal. a Origin dorsal nearer origin of caudal fin than end of muzzle. Upper lip not pendent; head one-fifth length to end of caudal; upper lip wide, D. 11, V. 10; scales tr. l. 30; ventral fins small.	*M. delphinus.*
aa Origin of dorsal fin nearer end of muzzle than basis of caudal. Head five and a half times in length with caudal; upper lip wide, not pendent; isthmus wide; eye, one-fifth, head; l. tr. 30; D. 11, V. 10; a light band on side.	*M. bardus.*

CATOSTOMUS SUCKLII, Girard; United States Pacific Railroad Report, X, p. 226, Pl. LI.—Waters of the Platte.

CATOSTOMUS LATIPINNE, Baird and Girard; Pr. A. N. Sci., Phil., 1853, 388; United States Mexican Boundary Survey, III, 39, Pl. XXIV, 1-6. (*Acomus*, Girard.)—Two heads from the Green River.

CATOSTOMUS GRISEUM, Girard; Pr. A. N. Sci., Phil., 1856, 174; United States Pacific Railroad, X, 222, Pl. XLIX, figs. 5–9.—Two specimens from Horse Creek, (waters of the Platte, August 27th,) one from Red Cloud Creek, and three from other waters of the Platte.

CATOSTOMUS DISCOBOLUS, (COPE;) sp. nov.

Remarkable for its very large lips, especially the upper. In general it is allied to the *C. griseum*, being of the same cylindric form. The upper lip is pendent, and somewhat expanded all round. Its margin extends outside of that of the lower lip, where it joins it, thus forming an entering right angle with it. The commissural margins of both are wide and abruptly separated from the tuberculated portions. Tubercles subequal; those of the lower jaw projecting in a convex enlargement, concentric with the lower commisure; behind deeply incised. Muzzle projecting a little beyond upper lip; head wide, flat above; eye superior, small, entering length of head 5.5 times; three times in muzzle. Phryngeal bones expanded below; teeth delicate laminar, with acute inner cusp. Length of head, entering total to end of caudal scales, four and a half times; ventral fins originating opposite posterior third of dorsal, barely reaching vent; pectorals well separated; isthmus very wide. Radii, D. 11; A. 8; V. 9. Scales in 38–40, longitudinal series between dorsal and ventral fins; color, olive brown above, black on head, passing into light yellow below, gradually on the body, abruptly on the head.

	M.
Total length	0.153
Length to orbit	.016
Length to opercular border	.029
Length to dorsal fin	.065
Length to ventral fin	.0695
Length to anal	.097
Width of frontal bones	.011
Length of ventral fins	.022

Two specimens, one certainly, the other probably, from the Green River, Wyoming. This striking species was discovered by Cam. Carrington.

This species may be compared with the *C. plebeius*, Girard, and *C. generosus*, Girard. In the first the eye is larger and more median, the scales are subequal, and there are only eight ventral rays. In the second the eye is also larger. In neither is the great development of the lip seen.

MINOMUS DELPHINUS, (COPE,) sp. nov.

The subequal size of the scales of this species would refer it indifferently to the true group Catostomus of Girard, or his group Minomus, which he did not distinguish clearly. The preceding species would enter his Acomus, which is, however, only an undefined group of species, to which, by the way, the type of *Catostomus*, *C. teres* belongs.

This species is especially distinguished from those heretofore described by the shortening of the caudal part of the vertebral column, and the consequent posterior position of the dorsal fin. Add to this a short, wide head, and thick body, and its physiognomy is expressed.

The dorsal outline is arched, the head flat above, but elevated behind, and much depressed on the muzzle. The muzzle is wide and does not project beyond the upper lip, which is appressed to its lower face and bears four rows of warts; its smooth commissural part is narrow. On the lower lip the tubercles advance nearly to the commisure; this lip is deeply emarginate posteriorly; the eye enters the length of the head five times, two and one-half times measuring the muzzle, and twice the interorbital region. Head four and two-thirds times in length to end of caudal basal scales.

Scales in thirty longitudinal series, between dorsal and ventral fins; ventrals remarkably short, extending little more than half way to vent, originating under posterior third of dorsal. Pectorals well separated. Radii, D. 11; A. 8, V. 10. Isthmus wide.

Color above blackish, with a strong inferior marginal shade on the lower part of the sides, and lighter tint above; a brown spot just above axilla, is cut off from it by a band of the yellow color which covers the belly and head below.

	M.
Total length	0.149
Length to orbit	.013
Length to opercular border	.0295
Length to dorsal fin	.069
Length to ventral fin	.074
Length of ventral fin	.015
Length to anal fin	.097
Interorbital width	.0115

The only species concerning which any doubt can arise in the nomenclature of this one is the *C. bernardini* of Girard. That writer states that the latter possesses 15 D. radii; this, with the ascription of a slender form and other peculiarities, will always separate them.

Three specimens in Professor Hayden's collection without locality. This should be probably a tributary of Green River.

MINOMUS BARDUS, (COPE;) sp. nov.

This species is distinguished by its very short head, and marked coloration, resembling in that respect the *C. guzmaniensis* of Girard; with this species it has, however, nothing else in common.

Head wide, muzzle not projecting beyond upper lip; latter not pendent, with narrow, smooth commisure and three or four rows of tubercles. Lower lip deeply incised, tubercular to near inner edge. Eye 5.25 times in length of head, twice in interorbital width. Head five times to end of basal caudal scales. Form stout; body cylindric anteriorly. Dorsal fin nearer end of muzzle than end of caudal scales. Scales of body subequal, in thirty longitudinal rows between dorsal and ventral fins; latter originating beneath hinder border of dorsal, not quite reaching vent. Pectorals well separated; isthmus wide, narrower than in *M. delphinus*. Radii D. 11, A. 8, V. 10.

Color, blackish above, a broad olive band from upper part of opercular border along upper half of caudal peduncle, and a broad black band below, narrowing to a line along the middle of the peduncle. Below, yellowish, a band of the same cutting off a blackish area above the axilla, as in the last species.

	M.
Total length	0.128
Length to orbit	.01
Length to opercular border	.0235
Length to dorsal fin	.059
Length to ventral fin	.0695
Length of ventral fin	.017
Length to anal fin	.086
Interorbital width	.0095

From the same locality as *M. delphinus*.

PTYCHOSTOMUS BUCCO, (COPE;) sp. nov.

A stout species, with a head short and particularly wide through the opercula. Lips thin, the inferior consisting of lateral lobes inclosing a V-shaped interval. Superior lip narrow, not pendent. Muzzle slightly projecting, subtruncate in profile. Eye large, 3.5 times in length of head, 1.2 in muzzle, and nearly .75 of interorbital width. Front and vertex flat; width behind orbits 1.75 times in length of head. Head one-fourth length without caudal, and equal to depth. Scales, 6–40–5. Radii, D. II. 12; A. II. 7; V. 9. Dorsal nearly median on superior outline. Pharyngeal teeth typical, *i. e.*, pectiniform, with slightly prominent inner angle.

Color uniform; dorsal fin dusky. Total length of young. M. .117; to opercular margin .0255; to ventral fins .0545. From St. Josephs, Missouri.

This species is allied most closely to the *P. collapsus*, Cope. This is a still stouter species, the depth entering the length only 3.5 times; the eye is smaller, being .2 of the head's length. The *Catostomus suckleyi* resembles it, but is more slender, and belongs to another genus. The *P. bucco* is named from the interopercular width of the head.

Cyprinidœ.

(CAMPOSTOMA ANOMALUM, Raf. Icth. Ohiensis.) *(Rutilus.)* Agassiz, Cope; Trans. Amer. Philos. Soc., 1866, 396.—Probably from the head-waters of the Platte River.

COLISCUS PARIETALIS, (COPE;) gen. et. sp. nov.

Char. genericus: Group IV. of the tribe Epicysti, (Trans. Amer. Phil. Soc., 1866,) and therefore with cultriform teeth arranged 4–4, and elongate alimentary canal, coiled many times below the swim bladder. The lateral line is almost entirely wanting, and the dorsal fin originates above a point in front of the ventrals. The lips are exceedingly attenuated, and the mouth directed upwards. Allied to *Hybognathus*, Agass.

Char. specificus: Head wide; especially behind, contained 4.25 times in the length without caudal fin. Muzzle obtuse; lips equal; mouth descending obliquely, the end of the maxillary not quite reaching the line of the anterior margin of the orbit. Eye 3.6 times in length of head; 7 times into muzzle, and 1.5 times into interorbital width. Scales small; l. tr. 14; l. long. 42; seven behind operculum, bearing tubes of the lateral line. Radii D. I. 7; A. I. 8; V. 9. General form moderately elongate; dorsal fin intermediate between end of muzzle and basis of caudal. Depth at dorsal, 4.6 times in length without caudal. Suborbital bones slender. Color everywhere white, silver on the sides of the head. Length, M. .0432. From the Missouri River near to St. Josephs. (Mus, Chicago Acad. Sciences, No. 575.)

HYBOPSIS MISSURIENSIS, (COPE;) sp. nov.

Belonging to group B, *i. e.*, with teeth 4–4, and mouth inferior Form stout, with large head and thick caudal peduncle. Head 3.75 times into length without caudal fin; scales, 5—31–2—3.

Dorsal outline a little arched; depth 4.5 times in length, without caudal fin. Eye three times in length of head, equal muzzle, four-fifths.

interorbital width. Profile, plane; parietal region wide; muzzle descending; upper lip projecting a little beyond lower; end of maxillary bone reaching line of orbit. Twelve scales in front of dorsal fin. Least depth of caudal peduncle two and a half to three times in length from first anal ray. Radii, D. I. 8; V. 8. Pectorals nearly reach ventrals; ventrals reach vent. Dorsal nearer end of muzzle than basis of caudal. Length, M. .05.

Light olivaceous, below paler; a silver lateral band and small dark dot at base of caudal fin. No dark dorsal band.

From near St. Joseph, Missouri. From the Mus. Acad. Sciences, Chicago.

This Hybopsis is near the *H. procne*, Cope, from the East. It differs in the generally stouter form, the larger head and thicker caudal peduncle.

HYBOPSIS SCYLLA, (COPE;) sp. nov.

Belonging to the group B. (Trans. Amer. Philos. Soc., 1866, 380) of this genus, and therefore allied to *H. stramineus* and *H. procne*, Cope. It differs from the former in its more slender form, and from both in the increased number of longitudinal series of scales.

Head 4.5 times in length without caudal fin; eye 3.5 times in head; scales 6–34–4. A. I. 7.

This species has a short head with obtuse muzzle. The lips are equal and the mouth slopes a little downward, the end of the maxillary reaching the line of the interior margin of the orbit. Length of muzzle .75 diameter of eye, which is little less than interorbital width; teeth 4–4; depth of body at first dorsal ray 4.6 times in length to basis of caudal; at caudal peduncle equal from orbit to opercular border. Ventral fin originating below D. I. Rays, D. I. 8, A. I. 7, V. 8; lateral line slightly decurved medially. Total length, 0 M. .0545. Color silvery with silver lateral band, marked with black points, which are especially abundant on the side of the muzzle. From Red Cloud Creek, a tributary of the Platte.

HYBOPSIS EGREGIUS, (GIRARD.)

(*Tigoma.*) United States Pacific Railroad Reports, X, 291.

What I suppose to be this species presents a well-marked grinding surface on one tooth (the second) on each side. There is nothing to distinguish Girard's *Tigomæ*, with this surface developed, from my section D of *Hybopsis.* (Trans. Amer. Philos. Soc., 1866, 382.) These species are his *T. gibbossa*, *T. nigrescens*, *T. pulchra*, and *T. crassa.* The teeth are 4.1(2)–1(2).4, and the mouth more or less oblique. They cannot be separated, as a genus, from *Hybopsis.* The *Tigomæ*, without masticatory surface, are closely allied to the *Clinostomi*, from which they differ in having the teeth 4.2–2.4 instead of 4.2–2.5. Some of Girard's *Tigomæ* appear to be true *Clinostomi.* Five specimens from Green River.

PHOTOGENIS PIPTOLEPIS, (COPE;) sp. nov.

This species has much the physiognomy of *Ceratichthys dissimilis*, Kirt., and is allied to the same genus. Dorsal region alongside and in front of the dorsal fin, scaleless; scales at dorsal, 3–4—36—2–3. Radii, D. 1.7, A. 1.8, V. 7. Teeth, 4.1–1.4; head, one-fourth length without caudal; depth, 4.66 times in the same; eye oval, diameter a little less than length of muzzle, 3.5 times in length of head and a little less than interorbital diameter; the mouth is nearly horizontal, and the muzzle descends gradually to it without projecting; maxillary extending beyond the line of the orbit; interorbital region convex.

In general proportions this species is rather elongate, with elongate head and small mouth. Length 0 M. .07. First ventral and dorsal radii opposed and a little nearer the end of the muzzle than the base of the caudal fin. Color above olive, below silver; a broad silver lateral band with black dots on each side of the lateral line, and a band of specks on the side of the head. A strong black dorsal band. From the North Platte.

In two smaller specimens, apparently of this species, there are some peculiar differences. In one the back is half scaled, the other entirely scaled, and the count is 6–36–4. The caudal peduncle is a little shorter, so that the dorsal fin has a median position; and the head enters the length (without caudal) 37 times. From the Red Cloud Creek.

HYPSILEPIS CORNUTUS, Mitchell, Cope, Proceed. Acad. Nat. Sci., Phila., 1867, 158.—Red Cloud Creek.

CYPRINELLA BILLINGSIANA, (COPE;) sp. nov.

A rather stout fusiform species, having the depth .25 of the length without caudal fin. Length of head the same; eye contained in it 3.5 times, .75 of interorbital width. Parietal and frontal regions convex transversely. Lips equal; mouth slightly descending; maxillary bone reaching line of orbit. Muzzle nearly equal to orbit's diameter. Scales, 6–31–3. Radii, D. I. 8; A. I. 8 (9;) V. 8; originating considerably in advance of line of dorsal fin; not reaching vent. Pharyngeal teeth 4.1–1.4.

Color in alcohol reddish above, *i. e.*, transparent in life; sides and operculum silvery. A faint median dorsal shade; no spots on fins or at base of dorsal. Total length, M. 048; end of muzzle to dorsal fin, .021. From St. Joseph, on the Missouri River; Dr. William Stimpson.

This fish differs from all those referred to *Cyprinella* by Girard, in proportions, radial or scale formula, excepting the *C. lugubris*, Girard. This species differs in having the dorsal fin above the ventrals, and in the upper regions of the body being dark brown. Dedicated to Joshua Billings, author of original observations on "The Briny Codfish."

MONIANA JUGALIS, (COPE;) sp. nov.

Form stout, back much elevated, descending steeply to the end of the muzzle. Head one-fifth of total with caudal fin; depth one-third without caudal fin. Eye 4.3 and four times in head's length, .6 of interorbital space. Upper lip a little more prominent than lower; end of maxillary bone falling behind the line of the margin of the orbit. Pharyngeal teeth 4–4 in adults; 4.1–1.4 in small specimens. Scales with narrow exposed surfaces, 7–34(3)–4(3.) Radii, D. I. 8; A. I. 9; V. 8, reaching anal, and originating well in front of line of first dorsal spine. Pectorals nearly attaining ventrals. Total length, M. .0665; to dorsal fin, .03; depth at last anal ray, .009.

Sides and ventral and anal fins, milky white; a median dorsal shade, a broad vertical bar behind the head, and an undefined shade on the side between origins of ventral and anal fin, of a sooty color. From St. Joseph, in Northwestern Missouri; Mus. Chicago Academy Sciences.

This species is well distinguished from those described by Girard in the reports of the United States commissions on the Pacific Railroad and Mexican boundary surveys. Thus, in the allied *M. leonina*, Girard, the depth is .25 the length; in *M. laetabilis* and *M. deliciosa*, Girard, the eyes are .3 of the head only; in *M. tristis*, the anal radii are I. .7; in *M. couchii*, perhaps the closest ally, the depth enters the length 3.5 times; the transverse scales are 7–3, anal rays I. .8.

The affinities of this species are plainly with such species as *Hypsilepis analostanus*, Girard, and *Photogenis pyrrhomelas.* It is interesting to observe that in its young state it possesses the single tooth of the inner row which characterizes the genus *Cyprinella*, which thus presents an *exact parallelism** to the immature stage of *Moniana*, as no other characters exist to distinguish the genera. I may add that Heckel and Kner have shown that the young teeth of the carnivorous type in European *Cyprinidæ* are pectinated. That the same is true of American genera I have often had occasion to observe. *Cyprinella*, then, in this respect presents an exact parallelism to *Photogenis*, or such species as *P. pyrrhomelas*, which only differ generically in the lack of this pectination at maturity.

M. jugalis in youth is thus a *Cyprinella*, and resembles no little the *C. billingsiana*, Cope, from the same locality. The latter has occasionally nine anal radii, and rarely the *M. jugalis* losing a row of scales above the lateral line, causes a still nearer approach. The smaller eye, deeper body, and color will always distinguish the young of the latter from that of the former.

ALBURNELLUS PERCOBROMUS, (COPE;) sp. nov.

A small species of moderately elongate form, and acuminate muzzle. Ventral fins reaching to line of last dorsal ray, not anal; pectorals nearly reaching ventrals. Scales 7–37–3; radii D. I. 8, the first originating opposite the middle of the ventral fins; A. I. 11 (10.) Head 3.75 times in length without caudal fin; depth of body 4.75 times into the same. Eye 3.5 times into head, equal length of muzzle. Mouth oblique, lips equal when closed, end of maxillary extending beyond line of orbit. Pharyngeal teeth 4.2–2.4. Seventeen rows of scales in front of dorsal fin. Length, M. .05; to origin dorsal fin, .023; to origin of anal. .0263.

Color pale, with lateral silver band. Dorsal scales minutely punctulate; basis of caudal the same, but without black spots. From St. Joseph, Missouri.

In technical characters this species approaches the *A. matutinus*, Cope, but that is much more slender in all respects and has smaller dorsal scales. Twenty-five of these cross the back in front of the dorsal fin in *A. matutinus*, seventeen in *A. percobromus*. For an analysis of the species of this genus see Proceedings Amer. Phil. Society, 1870, 464.

In the same collection occurred the percoid fishes *Lepomis anagallinus*, Cope, and *Boleosoma brevipinne*, Cope.

SARCIDIUM SCOPIFERUM, (COPE;) sp. et gen. nov.

Char. genericus.—Teeth 4–4, hooked, prehensile; alimentary canal short. No barbels, upper lip projectile; lower jaw without lip except below the canthi, where is a fleshy lobe on each side. Lateral line present; dorsal fin anterior to the ventrals.

This genus is allied to *Exoglossum* and to *Photogenis.* Its appearance is quite that of the former, especially in the mouth; when examined the rami of the mandible are not found to be united or in contact throughout, as is the case with *Exoglossum*, but they form the usual arc, but with a more

* See origin of genera, p. 7.

than usually stout symphysis. The form of the lower lip and anterior position of the dorsal fin separate it from *Photogenis.* As the dorsal fin is immediately above the ventrals in *Exoglossum maxillingua*, and as Girard represents its position to be the same as in *Sarcidium* in his *Ex. mirabile* from Texas, (United States Pacific Railroad Report, X, plate LVI,) I suspect that the latter will be found to be a species of *Sarcidium.*

Char. specificus: General proportions medium, the back nearly straight; the caudal region stout; the head rather small, with long and prominent but obtuse muzzle; mouth entirely inferior, the end of the maxillary about reaching the line of the anterior nares; length of head into total, without caudal fin, four times; depth at dorsal into same, 4.75 times; origin of dorsal nearer end of muzzle than basis of caudal fin; eye 4.2 times in length of head; 1.6 times in muzzle, nearly equal interorbital width; vertex nearly plane; profile slightly convex to a point opposite front nares; here it descends into a deep transverse notch, which is caused by a failure of the spines of the premaxillary to reach the nasal bones; preorbital bone long and narrow; lateral line nearly straight; scales 6–44–5; fin radii, D. I. 8; A. I. 7; V. 8; pectorals not reaching ventrals; ventrals reaching vent, which is a little in advance of the anal fin; length, M. .0545; depth at last anal ray, .006.

Color, olivaceous, (reddish in alcohol,) with a straight silver lateral band; this terminates in a strong black spot at the middle of the base of the caudal fin. No dark dorsal band.

This peculiar little fish was taken in the Missouri River, near St. Joseph, Missouri. (Mus. Chicago Acad. Sciences.)

GILA ELEGANS, Baird and Girard, Sitgreaves's Expedition. Zuni and Colorado, 1853, 149, Fishes, Pl. II.—Fort Bridger, two specimens; Forks of Green River, two specimens.

GILA GRAHAMII, Baird and Girard; United States Mexican Boundary Survey Report, Fishes, p. 61, Pl. XXIV, figs. 7–12.—Fort Bridger, one specimen; Henry's Fork, one specimen.

GILA GRACILIS, Baird and Girard; Sitgreaves's Report, 1853, 151, Pl. III.—Fort Bridger, one specimen; Henry's Fork, two specimens; Forks of Green River, five specimens.

GILA NACREA, (COPE;) sp. nov.

Allied to *G. grahamii*, Baird and Girard. Radii, D. 2. 9; C. 6. 10. 11. 6; A. 2. 10; V. 9; P. 14. Scales, 21—13. Length of head four times in total to basis of median caudal radii; depth at dorsal fin four and three-fifths times in the same. Ventrals originating in advance of dorsal fin, not reached by the pectorals. Least depth of caudal peduncle 2.5 times into the depth at ventral fins. Profile and interorbital region gently convex; width of latter 3.1 times in length of head; diameter of eye five times in length of head, and 1.25 times in length of muzzle, end of maxillary not reaching line of orbit. Teeth 4.2–2.5. Total length, M. 0.136; depth of head at orbit, .015; width of head behind, .0125; length of head, .028; depth caudal peduncle, .007. Color, silver-white; back narrowly dark shaded; pectoral fin, pink. From the fork of the Green River near Fort Bridger, Wyoming Territory; collected by Cam. Carrington, of Dr. F. V. Hayden's expedition.

This species is near the *G. grahamii* in number of anal rays and general proportions, but has a less depressed form of cranium and much larger eye. The head is more like that of *Ceratichthys* and ordinary *Cyprinidæ.*

SEMOTILUS CORPORALIS, Mitchill, Cope, Trans. Amer. Philos. Soc., 1866, 363, Platte River; Red Cloud Creek.

CERATICHTHYS SQUAMILENTUS, (COPE;) sp. nov.

Most nearly related to section III, (Trans. Amer. Philos. Soc., 1866, p. 365,) and therefore to the *C. prosthemius*,* Cope, but differing from the latter in its very much smaller scales. General form stout; length of head entering that of body, exclusive of caudal fin, 3.8 times; depth entering the same, five times; eye 4.6 times in length of head, $\frac{2}{3}$ length of muzzle, and .6 interorbital width. Parietal region convex; profile nearly plane; muzzle not prominent. Mouth horizontal; maxillary bone not reaching orbit. Dorsal fin considerably nearer the base of the caudal fin than the end of the muzzle, and originating a very little in advance of the origin of the ventrals. Radii, D. 1. 8; A. 1. 7; V. 7, extending to anal, pectorals not reaching ventrals. Isthmus rather wide. Teeth 4.2–1.4. Scales small, 17–66–14, covering both dorsal and thoracic regions completely. This description is taken from a small, probably young, specimen; length, M. .058. The barbels are short and slender and easily overlooked.

Above olive, below silvery; a lateral band of blackish dust from the head to the base of the caudal fin, widening behind; a black band round muzzle; sides and back black dusted. Fins unspotted.

From Henry's Fork of the Green River, Wyoming. Cam. Carrington discoverer. Several specimens.

RHINICHTHYS MAXILLOSUS, Cope; Proc. Acad. Nat. Sci., Phil., 1864, p. 278. Numerous specimens from Red Cloud Creek and the Platte. In life the upper lip, ventral and anal fins, and inferior aspect of caudal peduncle, are vermillion.

Siluridæ.

NOTURUS FLAVUS, Rafinesque.—From the waters of the Platte; identical with those from the Ohio.

IX.—MATERIAL RESOURCES.

REPORT ON THE INDUSTRIAL RESOURCES OF WESTERN KANSAS AND EASTERN COLORADO.

BY R. S. ELLIOTT.

An article by Professor J. G. Cooper on "The Forests and Trees of Northern America, as connected with Climate and Agriculture," appeared in the Agricultural Report of the Commissioner of Patents for 1860. In Professor Cooper's division of the continent into "provinces" the word "campestrian" is used to express the "most marked characteristic of the prairie and great central plain regions of North America, which consists in their comparative destitution of forests and nearly uniform surface, gradually rising from the Gulf of Mexico to the base of the Rocky Mountains, where they attain an elevation of 4,000 to 5,000 feet." The campestrian province, whose eastern boundary is the west

* Deceived by some specimens in the Liverpool Museum, Dr. Gunther has described this species in the Catal. British Museum as the *Gobio plumbeus* of Agassiz. A consideration of Professor Agassiz's description makes it apparent that a very different fish was the subject of it, probably, as Girard has observed, a species of *Semotilus*.

line of the Appalachian, or more densely-wooded, province, is subdivided into several regions, two of which, the Dakota and the Comanche, divided by the thirty-eighth parallel, stretch from the ninety-seventh meridian to the Rocky Mountains.

The general course of the Kansas Pacific Railway is on the thirty-ninth parallel, and in the "Dakota region" of Professor Cooper; but the country traversed partakes of the character of both regions at least as far southward as the Arkansas.

That portion of the State of Kansas east of the ninety-seventh meridian (which crosses the railway near Abilene) is so well known and established as a domain of great natural resources, arable and pastoral, that extended remarks on it are unnecessary. Near Abilene, eastward, we find the permian rocks in the bluffs of the Smoky Hill River and other streams. These rocks are overlaid by a soil of great fertility, more or less arenaceous, but similar to the loess or bluff deposits further east. Near Topeka the upper carboniferous rocks are on and near the surface—the line of separation between these and the permian not very distinctly defined. The carboniferous series extend to and across the Missouri River. The formations are so generally covered with earths of productive character that no rocky districts of meager fertility are found near the line of the railway. No swamps or unproductive areas impair the healthfulness of the country, or affect its capacity to sustain life. Water is abundant—generally of excellent quality; timber is plentiful in many localities; and coal is known to be obtainable over thousands of square miles. This notice of the country along 162 miles of the railway, from Abilene east to State line, is given in order that we may have in a single view the entire line of the railway from State line to Denver.

WEST OF NINETY-SEVENTH MERIDIAN.

The track at Abilene is 1,057 feet above the level of the sea. In 53 miles westward, at Summit Siding, (2½ miles east of Fort Harker,) the railway track rises to 1,556 feet, or 499 feet higher than at Abilene—an average of nearly 10 feet to the mile. This elevation is on a part of the road which cuts off a bend of the Smoky Hill River. At Ellsworth, 60 miles from Abilene, the track is again in the vale of the Smoky, and is 1,440 feet above the sea—116 less elevation than at Summit Siding, and 383 greater than at Abilene. From Abilene to Black Wolf, 10 miles west of Ellsworth, we have a sandy soil on the uplands, nourishing a rich growth of grass, and productive under the plow; in the bottoms a darker loam, containing more clay as a general rule, but having all the elements of permanent fertility. Rocks appear in the bluffs and banks of streams; also in limited areas on the surface of the uplands west of Salina, and in picturesque buttes, ledges, and crests between Brookville and Fort Harker.

The geological age of the country from Abilene to Black Wolf has not been very positively defined by any geologist whom I have read. I take it to be triassic, merging on its western border between Black Wolf and Wilson Station into "Cretaceous No. 1" of your classification, which, in the highlands north of Wilson and in the bluffs of the Smoky, south, appears to me to be very distinctly overlaid by your "Cretaceous No. 2." The decomposition of the triassic rocks, clays, and shales west of Abilene has left a kindly soil for the plow, except in the limited areas where too rocky for arable uses; and in these the native vegetation affords excellent pasturage, and promises well for tree culture in the future. The farmers near Brookville, Harker, and Ellsworth, as well as those at some distance north and south, find even the raw soil of the prairie productive the first season. Near where I write winter wheat gives unusual promise on sod broken for the first time last summer.

In general terms, the country from Abilene to Wilson (77 miles) may be classed as rich in soil and abounding in supplies of water, either in streams or reached by shallow wells—a country both arable and pastoral, and being rapidly taken up by immigrants. Abilene is prominent as a point for cattle shipment, increasing year after year. During the past season large numbers have also been shipped from Brookville; and in a year or two the herds will be coming to the track at Ellsworth and Wilson. As the consumption of beef seems to be gaining on the supply, there must be continuous activity in the cattle trade, and its magnitude will only be limited by the rate of increase of the animals.

WEST OF NINETY-EIGHTH MERIDIAN.

This meridian crosses the railway east of Fort Harker. At Wilson Station, 239 miles by rail west of the State line of Missouri, we are about 98° 30′ west longitude. We are now in the border of the immense cretaceous area, which, with more or less of superimposed drift, stretches westward to the eastern flank of the "great divide," so often described as extending east from the mountains between the waters of the Platte and the Arkansas. West of the one hundred and fourth meridian the cretaceous seems to be overlaid by tertiary formation, with lignite beds over large areas, extending at greater or less depths to the base of the mountains.

In describing the general formation from 98° 30′ west longitude to 104° as cretaceous, reference is had to what may be called the substructure. On the surface, over large areas, there are deposits of sandy clays and marls, with occasional solidification into porous strata of rocky character; in areas of limited extent looser sands and gravels, the latter in places intermingled with water-worn boulders of three to ten pounds weight, all apparently derived ages ago (yet recently in a geological sense) from the mountain ranges to the west and northwest.

In spots near Wilson, and at intervals westward to the one hundredth meridian, the cretaceous rocks are on the surface, and they are shown boldly in the bluffs of the Smoky Hill, Saline, and other streams. But further westward these rocks appear only in the bluffs of the streams, until about the one hundred and second meridian, where, in the neighborhood of Fort Wallace, some ledges of chalky limestone, variously tinted, rest in ledges on the uplands distant from the water-courses.

SOIL FOR SIX DEGREES OF LONGITUDE.

From the ninety-eighth to the one hundred and fourth meridian we have the traditional "desert." But there is no true desert on the line of the Kansas Pacific Railway. Between the one hundred and fourth meridian and the mountains the soil is in general of the same composition as that which at the base of the mountains has in many localities been proved to be remarkably productive. East of the one hundred and fourth meridian the external characters of the surface-earth suggest greater fertility than west of that line, and the native vegetation sustains this suggestion. In many parts of the plains there is a considerable mixture of vegetable mold with the surface deposits, particularly in the lower lands, and even in the most sandy and gravelly districts vegetation suited to the local conditions is always present.

Made up of disintegrated rocks and clays of cretaceous age, intermingled with, and in places overlaid by deposits of later drift, the general surface of the Plains east of the one hundred and fourth meridian may be described as composed of clay and sandy loam, with occasional but very limited spots of gravel—the whole impregnated with lime, gypsum, soda, magnesia, phosphoric acid, potash, and nitre; all fertilizers and true to their mission whenever the compacted surface is broken up so as to let in the air and moisture.

I repeat, that if we may judge by the native vegetation, the Plains may be described as productive over their whole extent, as traversed by this railway. There are zones and belts of greater and less fertility; but the language of Frémont, "broad, grassy plains," is as true in description as it is inconsistent with the idea of a "desert." "Broad, grassy plains," sustaining by their native plants animal life as ponderous as the buffalo herd, must have uses for mankind not belonging to a desert.

In some limited portions of this vast region there is only a scanty growth of the short, curly buffalo-grass *(Sesleria dactyloides)* with more or less of sage, cactus, and yucca. In large districts there is a general prevalence of grama-grass, *(Chondrosium fœneum,)* and eastward of the one hundred and first meridian we find a considerable intrusion of the Kansas "blue-joint," which notably increases as we approach the frontier settlements in the neighborhood of Wilson and Ellsworth. In all parts of the Plains there are spots of greater or less extent where the nutritious bunch-grass finds a congenial soil, and presents its rich pasturage. In the most arid and apparently most sterile portions of the country along this railway, cattle and mules and horses find subsistence and keep in good condition, where the flippant writer for the press, in a hurried journey by rail, has seen only "desolation," or has been nauseated by imaginary "alkali."

The cactus appears sparsely about the ninety-eighth meridian, perhaps some distance eastward, *(Mammilaria* and *Opuntia)* and is more abundant as we go westward, nowhere occupying the ground to the exclusion of grasses and other herbage. "A plant which is extremely useful to the Mexicans as a substitute for soap, by them called palmillo, by us Adam's needle or Spanish bayonet," *(Abert,)* the botanical name *Yucca augustifoleum*, appears but sparingly until we pass the one hundred and second meridian, but gains in number and vigor thence to the mountains. Artemisia appears in the western regions, but not in the abundance displayed in the Laramie Plains.

It is rare that any saline efflorescence is observed, until we get to the vale of the Big Sandy, a tributary of the Arkansas, reached by the railway at Kit Carson, near one hundred and third meridian. In the dry seasons pools of brackish water stand in the bed of this stream, and along its banks the white crystallization may be seen at intervals. The Smoky Hill River probably owes its repute as an "alkali" stream to the disintegrated chalk washed down from the layers of white or chalky limestone along its banks. In the bars of Big Creek, a living stream crossed by the railway near the one hundredth meridian, and which empties into the Smoky east of Fort Hays, the white limestone pebbles have no doubt passed with many observers as "alkali."

The proportion of the soil of the plains rendered unfit for production by "alkali" is not equal to the proportion of Illinois, Indiana, or Ohio rendered unfit by swamps and marshes. In fact, except in a very few basins, or depressions, a few acres in extent, where the drainage of surrounding areas is partly absorbed and partly evaporated, the soil is nowhere impregnated with alkaline matter to an extent to unfit it for general plant growth. Contrary to the prevailing impression, the alkaline soils are probably the most fertile where the necessary moisture is at hand. The "alkalies" are mainly in the clays and shales, and the soils resulting from the disintegration of these are apt to be the strongest. Moisture is needed on these soils, not to leach out the alkalies, but to furnish them in solution to the roots of plants, and to provide a humid atmosphere to surround the foliage.

In the gradual progression of settlements, the Kansas frontier moving west, and the Colorado coming east, to cover the entire Plains in the course of time, this vast region will be found to have as small a proportion of waste lands as some of the most favored States.

MINERALS—METALS AND COAL.

Westward from the ninety-seventh meridian, we are for ab ut seventy-five miles in the triassic region; rocks of the same age of those which, according to Whitney, are metalliferous in California. The Kansas rocks are apparently in place as deposited. No metamorphism, no grand upheavals, no outbursts of lava, have taken place. There may have been a gentle uplift of a few feet in the region adjoining Fort Harker on the east, the axis probably extending north and south; but even this gentle uplift is problematical, and is only suggested by springs coming out of the hills east of Harker, with a volume and permanence that can hardly be due to the local rain-fall. There *seems* to be a moderate curvature upward of the eastern edges of the strata, due either to their original deposition on the sloping beaches of the old triassic sea, or to a subsequent gentle upheaval; but even this curvature may be only fanciful, and the waters of the numerous springs near Harker and Brookville, some of which are at least 1,550 feet above the sea level, may come round in the "divide" between the Smoky and the Saline, from higher regions westward.

No metals are known with certainty to exist in this immediate region. Much of the sand-rock is impregnated strongly with oxide of iron, and many concretions of sulphuret of iron are found in the clays and shales. It is possible that other metals—gold, silver, tin, and antimony—might be traced. No examination with a view to metallic wealth has yet been made. There are traditions, said to come from the Indians, of tin and silver having been found near Salina, in the Smoky Hill region, but they are too vague to afford any clue to the mines, if any exist. I have been shown specimens of sulphuret and carbonate of copper, and of galena apparently argentiferous, said to have been taken from a locality very near Brookville; but the party in possession declined to give any information as to the place where found, or the probable quantity. Should the more valuable minerals, copper, lead, silver, &c., be hereafter ascertained to exist in this region, they will probably be in veins of segregated character lying in the planes of the general stratification, and not true veins, or lodes, traversing the strata. The copper-bearing stratum at Mansfeld, Prussia, is described by Whitney as "a bituminous marly slate," and in Silesia a similar slate is worked for copper; the beds being similar in character with some near Brookville, but I do not know their geological age.

Coal, according to all geologists who have written of Kansas, dips westward in the carboniferous formation, and is overlaid by the permian and later beds. Hence it may be found under the ninety-seventh meridian, but at what depth is yet entirely a matter of conjecture. In time it will no doubt be sought at some points west of all present mines;

perhaps at intervals of 50 miles along the railway west of Topeka. If the dip of the carboniferous series is really to the west or northwest, as generally held, the depth of the coal as far west as Abilene or Brookville may be too great for working until a greater demand shall grow up. A drill at Wamego, 100 miles west of Leavenworth City, could, at a cost of a few thousand dollars, tell us whether the veins of the Leavenworth shaft are persistent westward at a depth not beyond usefulness.

The coal found in the bluffs of the Smoky Hill River, opposite Wilson Station, though very recent, can hardly be classed as "lignite," if to be lignite it is necessary that wood should have contributed to its formation. The material is rather a carbonaceous or bituminous earth, in layers of one to three feet in thickness, with earthy partings, and breaking in cubical fragments, having the external characters of coal. It is used with advantage as domestic fuel; and, with changes in the grates and fire-boxes, could be made available in locomotives; while for stationary engines it will no doubt be extensively used as the country becomes more densely settled.

A coal said to be of better quality, but probably of similar origin and characteristics, is found in the bluffs of the Smoky, near the mouth of Big Creek, east of Fort Hays. A similar deposit is known near the town of Ellsworth. In boring for water at Bunker Hill Station, 12 miles west of Wilson, a stratum of two or three feet in thickness was drilled through, at a depth giving it a geological position similar to that of the coal opposite Wilson, which seems to be in the lower beds of your Cretaceous No. 2, or the upper of your No. 1. North of Wilson, in ravines leading to Saline River, I have found similar coal in small quantity, in position apparently identical with that in the bluffs south of Wilson.

When one particular stratum (or a limited series of beds) was in process of growth, there seems to have been deposited over a large area, in layers more or less continuous, combustible matter now mined as coal, and of much prospective usefulness as fuel. How far westward beyond the mouth of Big Creek, and how far northward or southward from the bluffs at Wilson this mineral fuel may in the future be discovered, cannot now be safely conjectured; but enough is known to justify the belief that it will play an important part in the development of an extended region, not only as domestic fuel, but also in the propulsion of machinery.

Borings at Ellis, near the one hundredth meridian, would, probably, in less than 300 feet, penetrate strata of the same age with the coal strata at Wilson, and in due time it is likely that examinations will be made. West of that point the strata are gradually covered to depths that will perhaps render this particular coal unavailable for many years. But if we have a store of fuel only so far west as Ellis, we are provided with this essential article for about three-fourths the length of the State of Kansas from east to west; and the western fourth of the State can, at a moderate cost, be supplied from the beds spoken of, or, if need be, from the mines near Cedar Point, about the one hundred and fourth meridian. Should all other sources of supply fail, we can (in this most improbable contingency) rely on the exhaustless stores of the mountains, already reached by rail. In any event, abundant fuel is available at all points on the line of this railway for the use of settlers in the woodless region. As the demand increases, and mining and transporting arrangements become more perfect, the cost will be so reduced as to meet the ability of all to purchase. Nature and art have thus already provided fuel for human uses on the Plains until forests can be grown, if desirable, to supply it.

BUILDING MATERIALS.

One of the most surprising features of life in Kansas is the importation of building materials in the shape of pine lumber from distant localities, when the State is so bountifully supplied in all parts with materials for the walls of houses at once cheaper and more desirable. The famous limestones in the bluffs of the Kaw Valley, where the mural treasures are fitted by nature for man's use, or readily shaped by the saw and plane, are succeeded on the west by sandstones at Abilene, Salina, Brookville, Harker, and Ellsworth, and by limestones at Wilson, Fossil, and other points westward to Hays and Ellis. Still farther westward, in the neighborhood of Fort Wallace, limestones appear of various pleasing colors, so soft as to be wrought with more ease than blocks of wood, yet hardening on exposure so as to sustain the weight of large buildings.

Lime may be cheaply made at numerous points on the railway. Immediately at the coal mines, near Wilson, are cretaceous limestones of excellent quality, from which lime may be produced at very small cost. The intelligent colonists, now looking for locations in the region about Wilson, where they expect to settle in 1871, will no doubt appreciate this valuable material.

Clays for brick and roofing tiles, as well as for all kinds of coarser pottery, if not for the finer, are abundant, as are also sands for mortars and concretes. So far as I have been able to learn, but little use has been made of concrete for buildings in Kansas, although the raw materials are abundant in almost every neighborhood.

In the climate of Kansas, even the adobes of New Mexico, well laid up in coarse lime mortar, with external plastering of the same, always provided the mortar is properly made and the unburned bricks thoroughly dry, would be preferable to any wooden walls, and less costly.

The future will witness a great change in the mode of building The imperishable materials so profusely scattered through the State will be made use of by a population wisely attentive to both economy and comfort. Kansas will become as famous for the solidity and taste of her buildings as for the rich and varied products of her soil.

Fences of stone have been constructed in many localities, and will soon be found in many more. Constructed of blocks regular in size, they combine a species of beauty with their obvious permanence, pleasing both to the eye and the judgment. It is, perhaps, not an unmixed misfortune that timber is so scarce, when the result of the scarcity is the durable stone fence and the living hedge.

WATER SUPPLIES WESTWARD TO ELLIS.

On the railway line the settlements may be said to extend a few miles beyond Ellsworth, about 225 to 230 miles west from State Line. On the Solomon and on the Saline, as also on streams south of the Smoky, settlers are some 25 miles farther westward. Up to the limit of present settlements water is as abundant and accessible as it is in Iowa or Missouri. It is established that in all of Kansas, near the thirty-ninth parallel, and east of 98° 30′ west longitude, there is no part where settlements are impracticable or need be retarded on account of the scarcity of water. In addition to the Republican, Smoky Hill, Saline, Solomon, and other constant streams, there are innumerable arroyos and courses in which water for stock is found in constant pools, or near which abundance can be had in shallow wells. It is also a pleasant fact that in the uplands the general rule is that water is accessible in all directions in wells of moderate depth, usually sunk without resort to blasting and unfailing in their supplies.

At Wilson Station, about 98° 30′ west longitude, water immediately at the railway track is abundant within 48 feet of the surface. South of the Station three miles is the living current of the Smoky Hill River; a few miles north is the Saline, and then the Solomon, all having tributaries of greater or less volume and permanence. At Ellsworth the railway makes its greatest southern bend opposite the northern bend of the Arkansas, which is within 50 miles, and the streams flowing into the Arkansas in that region are already flanked by the homes of pioneers whose numbers are rapidly increasing. The magnificent pasturage of that part of Kansas makes it the paradise of the stock-raiser.

The numerous springs near Wilson, some of considerable volume, and all yielding water of much excellence, would be worthy of note in any part of the Union, but could not be more happily located for usefulness.

West from Wilson the railway courses parallel with and not distant from the Smoky until approaching Hays, when it bears up the valley of Big Creek, an affluent of the Smoky. North Fork and Fossil Creeks are crossed between Wilson and Hays and again at Ellis. On the "divide" between the Smoky and Saline, followed by the railway from Wilson to Hays, water is found at depths corresponding to the undulations of the track and its elevation above the Smoky, and a short distance either north or south of the railway is available in springs, streams, and pools. Along the more elevated portions of the line, where deeper wells are required, the dense clays of the cretaceous series are at hand for cisterns and tanks to hold rain-water, and the thinner layers of the fossiliferous limestones afford easily-wrought materials of construction.

Thus we reach Ellis, 302 miles, and have been all along in a country sufficiently if not abundantly watered, and presenting where they may be required ample resources for the establishment of ponds, cisterns, and tanks, to retain the supplies which the clouds do not fail to yield. We are about half way from State Line to Denver, and 2,019 feet above the level of the sea, yet neither in the paucity of vegetation, nor in privation of water, nor in sterility of soil, have we found one feature of the traditional desert, with the single exception of the scarcity of trees, which are only found along the water-courses or in nooks of the bluffs where fires have not been able to reach them.

Ellis is a prominent station, with round-house, machine-shops, hotel, and stores. Big Creek, crossed at Ellis, is a constant stream with its source westward in the Plains. The Smoky Hill River is about 25 miles south, and the head streams of the Saline about the same distance north. Farming operations on a large scale are projected in the vicinity of Ellis, near the one hundredth meridian.

FROM ELLIS WESTWARD.

The railway pursues its general course directly westward, (the Smoky Hill River at an average distance of 30 miles south,) and rising on the divide between the drainage to the Smoky and that to the Saline and Solomon. There is no constant stream till we reach Sheridan, 103 miles from Ellis, where another "North Fork" is crossed; a stream of visible water sufficient for large herds of cattle and available for irrigation. There is evidence of considerable underground flow in the main as well as lateral valleys of the North Fork. It rises far to the north, in the higher lands in which the south branches of the Republican have their sources, and enters the Smoky about 15 miles south of Sheridan.

Between Ellis and Sheridan the superficial "drift," porous in character, covers the cretaceous clays and shales to a considerable depth, and water in wells is reached by sinking to the impervious clays. The railway company has been successful in wells from 90 to 130 feet in depth, securing supplies apparently inexhaustible. The railway track is located on the divide so as to head the lateral swales and ravines, on ground of greater average height than will be occupied by the future stock ranches or "estanchias;" and hence the water supplies of the latter will be more readily and cheaply obtainable in wells of less depth.

The North Fork, crossed at Sheridan, has in its main and lateral valleys many desirable locations for grazing establishments. Some of these locations will no doubt be taken up at an early day. A large rush valley, distant eight to ten miles north from Sheridan, would winter thousands of cattle. Extensive savannas yield a large annual supply of natural grass suitable for hay. Springs of excellent water, some of them sufficient for irrigating purposes, are known along the North Fork.

Thus we reach Sheridan, 405 miles by rail west of State Line, and yet have passed through no "desert" or uninhabitable country; nutritious grasses have been on either hand, and water within reach.

FROM SHERIDAN WESTWARD.

We cross two creek beds between Sheridan and Pond Creek, 17 miles; the contour of the country indicating that wells, not yet tried, could not fail of success. At Pond Creek water is plentiful in pools. Within a short distance southward the Smoky Hill, here a small stream, and Rose Creek, one of its tributaries, afford water for all purposes, with facilities for irrigation; the latter successfully applied, under the orders of General Woods, in the cultivated grounds at Fort Wallace. A short distance west of Pond Creek the Smoky is crossed, here a wide bed of coarse sand, with no visible water, but with a constant supply under the sand; not, however, of large volume, as we are now within a few miles of its upper arroyos.

In 40 miles, from Pond Creek to Cheyenne Wells Station, the railway rises 1,000 feet; reaching an elevation above the level of the sea of 4,179 feet, only 12 feet less than at Kit Carson, 25 miles farther west. At First View Station, 10 miles west of Cheyenne Wells, the elevation is 4,479 feet; 288 feet greater than at Kit Carson, where it is 4,191 feet. From First View there is a rapid descent to the vale of Eureka Creek, about 10 miles, and thence on a nearly level grade to Kit Carson.

Pond Creek being 3,175 feet, the track is 1,016 feet higher at Kit Carson; but in making this rise in 65 miles we pass over in the first 50 miles an immense swell of the plain, and at First View we are 1,304 feet higher than at Pond Creek. From Pond Creek to First View the track, heading lateral swales, follows "divides" where practicable; yet the destitution of water, which might be reasonably expected, is not experienced. At Eagle Tail, 3,336 feet above the sea, water is abundant in pools; and at Monotony (about 3,520 feet) is supplied by an unfailing well, 15 miles from Pond Creek. Along the track west of Monotony, until the descent is made to the vale of Eureka, it may, perhaps, be necessary to sink wells to a depth proportioned to the rise of the track; but no doubt is felt that even in the localities least favorable successful wells can be made. About six miles east of north from the Cheyenne Wells Station, on the railway, are the old shallow wells of the same name in the vale of the Smoky; used formerly to supply the overland stages, and now used by emigrants with teams and live stock. And the fact that emigrants traverse the Plains near the thirty-ninth parallel at their pleasure, without serious inconvenience from lack of water, ought of itself to establish the habitable character of the country.

Descending west from First View Station, we are in 10 miles at Eureka Creek; only an arroyo, but marking a depression in the plain, where, over an area of several miles square, water can be had in wells at the depth of a few feet; the water in the railway well at Eureka tank being within 10 feet of the surface. Five miles farther we are at Kit Carson, where, in addition to constant pools in Big Sandy, and unfailing supplies to a limited extent in the arroyo of Wild Horse, the large but shallow wells sunk for railway uses are apparently inexhaustible.

The artesian well at Kit Carson penetrates the clays and shales of cretaceous age, below the level of the percolations from the surface. It was undertaken before the abundance of the stores near the surface—resting on the clays, under the loam, sand and gravel—were known or supposed to exist. Its main object was a flowing stream, and this not being realized at 1,460 feet, and there being no necessity for more liberal supplies than are now enjoyed, the work has been suspended. The geological features developed by the well have been discussed in a former letter, and need not be treated here.

FROM KIT CARSON WESTWARD.

Along the railway for nearly 70 miles we have the Big Sandy and its tributary arroyos. Then at Cedar Point we cross the northern trend of the "great divide," and thence to Denver we are on the waters of Beaver, Comanche, Kiowa, Bijou, and Bear Creeks, and some minor streams. It is true that there are seasons when the water is not visible in the broad sandy troughs of these creeks, yet it is never absent, but is always in large quantities under the surface, accessible by shallow wells. Nature has kindly given it the shield of sand, as a protection against the warm air of summer; and thus saved from evaporation, it is with little labor brought into usefulness. In addition to the streams there are numerous springs between Kit Carson and Denver, some near and some distant from the track, and wells even on the high flanks of the divides would in most cases be successful. In the Godfrey coal mines, 5,505 feet above the level of the sea, water is encountered at various depths, in a shaft 108 feet.

The immense coal-field, which appears to dip gently to the westward from Cedar Point, in addition to supplying fuel in unlimited quantities, may yet, in the slope of the tertiary strata, afford successful artesian wells between Cedar Point and Denver. Having written of this coal-field in a previous letter, I only allude to it briefly in these passages as relating to coal supplies. While its coal treasures are beyond computation, it is possible that this "tertiary basin" may in time bear some resemblance to the Paris basin, so far as flowing wells are concerned. With the timbered region of the great divide on the south, water supplies in all its parts, I look for a rapid extension of settlements in the country between Cedar Point and Denver.

The foregoing presents, so far as it goes, a fair view of the water supplies along the Kansas Pacific Railway. Though in particular regions not abundant, water is yet greatly more copious in supply than the popular belief, and even some grave works of science, have heretofore held it to be. It may be said with safety, because with truth, that the entire space of 20 miles on each side of this railway, covered by its grant of lands, is available for human sustenance, so far as its utility depends on supplies of water in springs and streams, or its provision at reasonable cost in wells, cisterns, and tanks.

The nearest approach to destitution is between Pond Creek and Kit Carson. By reference to a correct map you will see that the Smoky Hill River has its sources (or upper arroyos) east and northeast from Kit Carson, the Republican is at a considerable distance northward and northwestward, while the Big Sandy is westward and southwestward. The eye at once appreciates the fact that here is a water-shed, curving round from about Cedar Point, passing north of Eureka Valley and turning southward past First View Station, giving us the swell in the plain which I have noted as existing from Pond Creek westward to First View. Now when the porous character of this region, with drift from 100 to possibly 500 feet in depth, is considered, we readily understand that the streams may be small or intermittent; arroyos, with occasional pools, not lasting, and running water only in times of heavy storms, and we are prepared for the phenomena which actually present themselves: invisible streams finding their way slowly under the earth, and a surface not cheered by brooks or rivers, though verdant with nutritious vegetation.

But let us consider the beneficence manifested, even where the absence of visible water may to the careless observer suggest desolation. Over this region there is an annual rain-fall, averaging from 15 to 20 inches; but let us take it to be but 12 inches. This gives 43.560 cubic feet of water on an acre in a year; about 340,000 gallons in the dooryard of the farmer; on each square mile nearly 28,000,000 cubic feet, or nearly 220,000,000 gallons. What becomes of this precipitation? If the surface were bare rock or impervious clays it would mainly pass off by floods, and the remnants left in depressions escape by evaporation. But the superficial deposits are of such porous character, over extended areas, that a large proportion of the rain-fall sinks into the earth, and is there stored in depressions of the clay sub-strata, ready for man's use as needed.

IRRIGATION.

A day will come, no doubt, when streams and wells along the line of this railway will furnish water for irrigation, to nourish such vegetation as will not thrive without it. The Smoky Hill River and many of its tributaries can be used, either by leading out the water from dams or forcing it to a higher level by machinery. It may be said that along or near the railway irrigation to a considerable extent from streams is practicable till we reach the one hundred and second meridian. Thence to about the one hundred and third meridian the water must be sought in wells, or the rain-fall stored in tanks for use as needed.

West of the one hundred and third meridian the Big Sandy, with a fall of about 17 feet per mile, can be utilized for irrigation up to and beyond the point where the track leaves its valley. Passing the divide at Cedar Point, we have Beaver, Comanche, Kiowa, Bijou, and Bear Creeks, together with springs and lesser streams; all with supplies of water to be rendered available in the future if required.

The fall of the streams above named is stated to be about 30 feet to the mile, and their waters can be led out at small cost. The canals at their commencement will partake somewhat of the character of the Afghanistan *caureez*, but will be less costly. In the sandy beds of the streams water rests on the impervious bottoms at the depth of 10 to 15 feet; and conduits, with a fall of 2 to 4 feet to the mile, will bring it out to the points where needed.

Power for raising water from streams or wells will be furnished by the winds, by cattle, or steam. If Ericsson succeeds with his solar engine it may come into use in this country of much sunshine. But the wind-mill, for irrigating purposes, particularly where water is to be raised from wells, is likely to be the main reliance.

The project of carrying the South Platte eastward from the cañon, in a grand canal along the divide, will no doubt be realized in a comparatively short time. Reaching past the heads of the streams crossed by the railway between Cedar Point and Denver, the canal, in fertilizing its million acres, will add to the quantity of water directly flowing from it as by its modifying influence on the climate.

The suggestion of J. A. Hodder, esq., of Cincinnati, that streams from the mountains might be led out to irrigate considerable districts, and the surplus water be accumulated in lakes for use as the vicissitudes of the seasons may require, will probably be found worthy of grave consideration as the population and the ability to accomplish large works increase.

While it is held that, in addition to natural grasses, there may be a large production of food for live stock, and of grains for bread, *without irrigation*, in many if not all parts of the Plains, it is yet equally certain that irrigation is essential for some kinds of vegetation in many localities. What would be a great benefit in Pennsylvania or Ohio, if applied, is absolutely necessary for full success with some particular crops in that part of the campestrian province west of the one hundredth meridian. Hence, in looking forward to the reduction of a vast region to productive uses, problems of irrigation are to be considered, and in due time they will be solved in the daily life of the future inhabitants.

CLIMATE.

The Plains have been so often described as a "rainless region," that great misconception in regard to the climate has prevailed. The absolute precipitation is much greater than has been in past years supposed, and is due to other causes. Meteorologists who have described the rainfall of the Plains as derived only or principally from the remaining moisture of winds from the Pacific, after the passage of the Nevada and Rocky Mountain ranges, have been greatly in error, and the better conclusion now is, with all authorities who have given any special attention to the subject, that the moisture which fertilizes the Mississippi Valley, including the broad, grassy plains, is derived from the Gulf of Mexico.

Within a few years the rain gauge has been brought into service at points distant from each other, but located at irregular intervals across the continent, and its record shows not only greater precipitation than was formerly believed to take place on the Plains, but that the distribution is unequal in time, giving us the largest proportion in the *growing seasons*, spring and summer.

In his late work, "The Mississippi Valley," Professor J. W. Foster says: "The rains which water the Atlantic slope are equally distributed, the variations between the four seasons being very slight," while "those which water the Mississippi Valley are unequally distributed, those of spring and summer being greatly in excess;" "a fact," he says, "which has been overlooked by most meteorologists in reference to the geological distribution of plants." As we pass westward from the Atlantic the inequality increases until we pass the Rocky Mountains. "Contrasting the two stations, New York and Fort Laramie," says Professor Foster, "it will be seen that on the seaboard about 48 per cent. of the yearly precipitation occurs during the fall and winter, while on the Plains only 25 per cent. occurs during that period, and that, while on the seaboard the precipitation is nearly uniform during the four seasons, *three-fourths* of the precipitation on the Plains occurs during spring and summer." The same excess in the rain-fall of spring and summer is, I think, noted with comments in Blodgett.

At Fort Riley about 69 per cent. of the annual precipitation is in spring and summer; at Fort Kearney 81, and at Fort Laramie 72 per cent. From observations at Forts Harker, Hays, and Wallace, on the line of this road, the same rule seems to hold good. Records have not been long enough continued at these three posts to give a long average, but the mean appears to be between 17 and 19 inches at Hays and Wallace, and possibly rather more at Harker. The actual average for 1868 and 1869 at Hays is 18.76 inches, and for the first six months of 1870 the record is 10.68 inches. At Wallace the record for 1869 was over 17 inches, and in 1870, up to October 1, about the same amount had fallen.

Without records there can be only conjecture; and I can only remark that there does not seem to be much diminution in the annual rain-fall until we get as far west as the one hundred and third meridian. Thence to the base of the mountains, (except perhaps in the timbered portions of the great divide, south of the line of this railway,) the annual average may be possibly two or three inches less than in the midst of the Plains: a peculiarity explained, hypothetically, by the fact that the region "lies to the westward of the general course of the moister currents of air flowing northward from the Gulf of Mexico, and is so near the mountains as to lose much of the precipitation that localities in the Plains east and northeast are favored with. The mountains seem to exercise an influence—electrical and magnetical?—in attracting moisture, which is condensed in the cooler regions of their summits, while the plains at their feet may be parched and heated to excess." This explanation may be fanciful, but the fact remains that near the mountains the rains seem to decrease north of the great divide; fortunately, however, this occurs in a region where irrigation may be applied extensively, and where there is sufficient moisture to nourish bountiful crops of grass.

A striking difference exists between the rain-fall in New Mexico and that on the Plains. While the annual amount at Santa Fé and at Fort Hays is nearly equal, the larger proportion of the rain-fall at Hays comes in *spring and summer*, while at Santa Fé it is delayed till *summer and autumn*. Hence the farmer at Hays may have his wheat crop matured in early summer without irrigation, while the same crop in New Mexico requires to be irrigated. The usual period for the nourishing rains to begin, in New Mexico, is about the first of August, a time when they are usually light on the Plains.

Theory suggested that the cereals ought to sustain themselves without irrigation at least as far west as the head streams of the Smoky Hill River; and the president and directors of the railway caused experiments to be made. Wheat sown in April last matured in July, about the one hundred and first meridian, yielding merchantable grain. Maize formed ears, and oats headed well, but neither filled in a satisfactory manner, owing to the fact that the dry and hot season comes on when their grains are forming. Both can be raised as fodder to any extent desired. All along the railway, throughout the season, stalks of maize and oats could be seen growing, where seeds had been dropped by accident. At Cheyenne Wells, 4,179 feet above sea level, beans matured along the road bed; and at First View, 4,479 feet, oats grew to the average height and matured its seed. Winter wheat, rye, and barley, now on trial as far west as Pond Creek, near one hundred and second meridian, are expected to yield well, though late sown on raw sod.

The vegetation of the Plains, along wagon-tracks and railroad embankments, shows a capability of production scarcely suggested by the surface where undisturbed. Wherever the earth is broken up, the wild sunflower *(Helianthus)* and others of the taller-growing plants, though previously unknown in the vicinity, at once spring up, almost as if spontaneous generation had taken place.

CHANGE OF CLIMATE.

In September last I wrote to Professor Joseph Henry as follows:

I have been on the Plains all the time since early in May till this date, (22d September.) There has been much dry weather, but I have not seen one cloudless day—no day on which the sun would rise clear and roll along a canopy of brass to the west. There has always been humidity enough to form clouds at the proper height; and on many days they would be seen defining, by their flat bottoms, the exact line where condensation became sufficient to render the vapor visible. * * * I conclude from all this that abundant moisture has floated over the Plains to have given us a great deal more rain than would be desirable, if it had been precipitated.

Sometimes a storm would be seen to gather near the horizon, and we could see the rain pending from the clouds like a fringe, hanging apparently in mid-air, unable to reach the expectant earth. The rain stage of condensation had been reached above, but the descending shower was revaporized, apparently, and thus arrested. * * *

These hot winds are not, so far as I have observed, apt to be constant in one place for any considerable length of time; they strike your face suddenly, and perhaps in a minute are gone. They seem to run along in streaks or *ovenfulls,* with the winds of ordinary (but rather high) temperature They do not begin, I believe, till in July, as a general rule, and are over by September 1, or perhaps by August 15. Their origin I take to be, of course, in heated regions south or southwest of us; but their peculiar occurrence, so capricious and often so brief, I cannot explain to myself satisfactorily.

I have no rain-gauge record at hand for this and past seasons; but I may remark that this season, since about the 15th of July, in these distant Plains, has given us rain enough to make beautifully verdant the spots in the prairie burnt off during the "heated" term in July. From Kit Carson eastward the rains have been, I think, exceptionally abundant. All through the summer we have had *dew* occasionally, and it has been remarked that buffalo-meat has been more difficult of preservation than heretofore; facts indicative of humidity in the atmosphere, even where but little rainfall was witnessed. Turnips sown in August would have made a crop in this vicinity, 422 miles west of the State line of Missouri. * * * * * * * * *

Facts such as these seem to sustain the popular persuasion in Kansas, that a *climatic change* is taking place, promoted by the spread of settlements westwardly, breaking up portions of the prairie soil, covering the earth with plants that shade the ground more than the short grasses; thus checking or modifying the reflection of heat from the earth's surface, &c. The fact is also noted, that even where the prairie soil is not disturbed, the short buffalo-grass disappears as the "frontier" extends westward, and its place is taken by grasses and other herbage of taller growth. That this change of the clothing of the Plains, if sufficiently extensive, might have a modifying influence on the climate, I do not doubt; but whether the change has been already spread over a large enough area, and whether our apparently or really wetter seasons may not be part of a cycle, are unsettled questions.

The civil engineers of this railway believe that the rains and humidity of the Plains have increased during the extension of railroads and telegraphs across them. If this is the case, it may be that the mysterious electrical influence in which they seem to have faith, but do not profess to explain, has exercised a beneficial influence. What effect, if any, the digging and grading, the iron rails, the tension of steam in locomotives, the friction of metallic surfaces, the poles and wires, the action of batteries, &c., could possibly or probably have on the electrical conditions, as connected with the phenomena of precipitation, I do not of course undertake to say. It may be that wet seasons have merely happened to coincide with railroads and telegraphs. It is to be observed that the poles of the telegraph are quite frequently destroyed by lightning; and it is probable that the lightning thus *strikes* in many places where before the erection of the telegraph it was not apt to strike, and perhaps would not reach the earth at all.

These remarks were sent to the distinguished meteorologist, Professor Henry, rather to draw the attention of his cultivated mind to the phenomena than to assert a theory. Yet there are facts which sustain the popular notion of a climatic change, manifested in a more humid atmosphere, in greater rain-fall and a change of vegetation. A gentleman who has given much attention to meteorology writes me that he is not satisfied that settlements have sufficiently changed the surface of the country west of the Missouri to affect the climate. "The increased rains," he says, "I apprehend, are due to extra mundane or cosmic influences not yet understood."

It is certain that rains have increased; this increase has coincided with the extension of settlements, railroads, and telegraphs. If influenced by these, the change of climate will go on; if by extra mundane influences the change may be permanent, progressive, or retrograde. I think there are good grounds to believe it will be progressive. Within the last fifteen years, in Western Missouri and Iowa, and in Eastern Kansas and Nebraska, a very large aggregate of surface has been broken up and holds more of the rains than formerly. During the same period modifying influences have been put in motion in Montana, Utah, and Colorado. Very small areas of timbered land west of the Missouri have been cleared; not equal, perhaps, to the area of forest, orchard, and vineyards planted. Hence it may be said that all the acts of man in this vast region have tended to produce conditions on the earth's surface ameliorative of the climate. With extended settlements on the Arkansas, Canadian, and Red River of the South, as well as on the Arkansas, on the river system of the Kaw Valley, and on the Platte, the ameliorating conditions will be extended in like degree; and it partakes more of sober reason than wild fancy to suppose that a permanent and beneficial change of climate may be experienced. The appalling deterioration of large portions of the earth's surface, through the acts of man in destroying the forests, justifies the trust that the culture of taller herbage and trees in a region heretofore covered mainly by short grasses may have a converse effect. Indeed, in Central Kansas, nature seems to almost precede settlements by the taller grasses and herbage.

TREE GROWTH ON THE PLAINS.

The principal native trees on the Plains west of ninety-seventh meridian are:

COTTONWOOD, *(Populus Canadensis* and *P. Monolifra.)*
WALNUT, *(Juglans Nigra.)*
ELM, *(Ulmus Americana.)*
ASH, *(Fraxinus Americana.)*
BOX ELDER, *(Acer Negundo.)*
HACKBERRY, *(Celtis occidentalis.)*
PLUM, *(Prunus Chickasa.)*
RED CEDAR, *(Juniperus Virginiana.)*

To these may be added WILLOW *(Salix)* and GRAPE VINES *(Vites œstivalis;)* and also the LOCUST *(Robinia pseudo-acacia)* and WILD CHERRY *(Cerasus Virginiana)* mentioned by Abert as occurring on the Purgatory.

The black walnut extends to the one hundredth meridian; how much farther I am unable to say. The elm and ash are of similar, perhaps greater range. Hackberry has been observed west of one hundred and first meridian. Cottonwood, box-elder, red cedar, plum, and willow are persistent to the base of the mountain.

The extensive pine forest *(Pinus ponderosa,)* on the "great divide" south of Denver, although stretching seventy to eighty miles east from the mountains, is not taken into view as belonging to the Plains proper. Its existence, however, suggests the use of its seeds in artificial plantations in that region. Settlers in the pinery or its borders would do well to protect portions of the forest by inclosure, and if possible against fire, as by suitable care the forest could be made perpetually remunerative and reproductive.

The fossil wood, imbedded in the cretaceous strata in many parts of the Plains, is left out of consideration, as belonging to a previous, though recent, geological age; but the single specimens of trees found growing at wide intervals are silent witnesses to the *possibility* of extended forest growth. These living trees suggest at once, by their location, the feasibility of their increase, and the *reason of their scarcity.* They are *usually* found near water; and hence we conclude that in order to grow trees we must break the ground so deeply as to save all the rains for their use. They are *always* where they are protected from fires; and hence we conclude that if we can protect our plantations from fires we can grow forests.

Were it possible to break up the surface to a depth of two feet, from the ninety-seventh meridian to the mountains, and from the thirty-fifth to the forty-fifth parallel, we should have in a single season a growth of taller herbage over the entire area, less reflection of the sun's heat, more humidity in the atmosphere, more constancy in springs, pools, and streams, more frequent showers, fewer violent storms, and less caprice and fury in the winds. A single year would witness a changed vegetation and a new climate. In three years (fires kept out) there would be young trees in numerous places, and in twenty years there would be fair young forests.

Nor is this view inconsistent with the conclusion of meteorologists that our prairies and open plains are due to scanty precipitation. This is the *cause;* not, however, because the absolute moisture is not enough to sustain the growth, but because it is not enough to protect it against destruction by fires. Throughout the prairies—the "Illinois region" of Professor Cooper's campestrian province—whenever the fires are checked, tree growth begins. Given immunity from fires on the Plains, and to a great extent, they will clothe themselves with shrubs and trees, even without a breaking up of the surface.

The limited area which it is in our power to turn up by the plow will have the same results in kind to follow a breaking of the entire surface, but less effective than if the operation were universal. Yet a beginning can be made by the railway company and by individuals. In fact, it is already in progress by settlers, a degree and a half west of ninety-seventh meridian. A few acres at intervals across the Plains, or only a few clumps of trees growing without irrigation, will be a demonstration more effective than theory.

In this great work the United States ought to lead, either by forests planted at the cost of the Treasury, or by subsidies to individuals or companies. It is a work worthy of the age, and of the nation.

The particular trees most suitable for first planting on the Plains, the modes of culture, the proper succession of species, cannot be treated in a paper already so extended as this. The feasibility of forest growth over this great area is, in my estimation, not to be doubted. The details will be wrought out in due time.

GRAZING RESOURCES.

The description of the "broad, grassy plains" given in the foregoing pages attests their capacity to sustain animal life. For cattle, sheep, horses, and mules they are a natural pasture in summer, with, in many parts, hay cured standing for winter. The famed pampas, with their great extremes of wet and drought, cannot bear comparison with our Western Plains. For grazing purposes, the habitable character of our vast traditional "desert" is generally conceded, and hence it need not be enlarged on here.

IMMIGRATION.

The settlers come singly and in groups, in families and colonies. It is not a crusade of fanatics, or a raid of fillibusters, but the measured march of earnest men and women seeking homes. The extension of settlements westward from the "frontier," and eastward from the mountains, must go on. Population increases, and lands are needed. Hence the occupancy of the lands along and near the line of this railway is an assured fact of the early future. It is an eventuality not created by the power of this corporation, but growing out of the circumstances of the nation, and the distribution of our landed resources.

It will seem to many a vast work to spread settlements over the "great Western Plains." To force such settlements would be a large task; but no forcing is needed. The facilities provided, the lands available, and the settlers throng in of themselves. Those who have doubts of the event should remember, 1st, that permanent settlements have already reached more than two-fifths the distance from Kansas City to Denver; 2d, that the facilities as well as the necessity for the future extension of settlements are day by day increasing; 3d, that the difficulties and hardships of frontier life diminish as means to overcome them are multiplied; 4th, that with a railway in operation the spread of settlements becomes a problem greatly less difficult than the construction of the road itself.

PART V.

CATALOGUES.

I. OF MAMMALS AND BIRDS. By MR. JAMES STEVENSON.
II. OF MOLLUSCA. By S. R. ROBERTS.
III. OF COLEOPTERA. By DR. G. H. HORN.
IV. OF HEMIPTERA. By PROF. P. H. UHLER.
V. OF PLANTS. By MR. THOS. C. PORTER.
VI. OF PLANTS. By DR. C. C. PARRY.

MAMMALS AND BIRDS.

A LIST OF MAMMALS AND BIRDS COLLECTED IN WYOMING TERRITORY, BY MR. H. D. SMITH AND MR. JAMES STEVENSON, DURING THE EXPEDITION OF 1870.

By James Stevenson.

As already stated in the early part of this report, the expedition did what was in its power, within the time at its command, to secure as complete a representation as possible of the vertebrate fauna of the country, and the list of these herewith submitted will show the measure of success. Although the collection of mammals and birds embraces no new species, yet it promises to be of value in determining with greater precision the geographical distribution, and the precise eastern limit of the western forms, and the western range of the eastern species, the region explored having been a kind of common or meeting ground of the two series. We regret that the late date at which the expedition was organized made it impossible to collect facts in regard to the nesting and the eggs of any of the birds, as it is in this branch of their history that most of novelty was to be expected. The immature plumage of the gray-crowned finch (*Leucosticte tephrocotis*, Sw.,) was, however, ascertained for the first time, and will be hereafter duly described.

As complete a collection of the mammals of the country was obtained as practicable, and embraces a considerable number of specimens of all the known Rocky Mountain forms. Among these may be specially mentioned the least or Nuttall's hare, a species scarcely more than six inches in length, and the smallest of all hitherto described; the little chief hare, allied to the true hares, but without any vestige of the tail, and the white-tailed prairie dog. This last-mentioned animal made its appearance after we crossed the divides of the mountains, and, as far as we know, is entirely peculiar to the region drained by the waters of the great interior basin; while the common prairie dog is equally characteristic of the western portions of the valley of the Missouri.

Mr. C. P. Carrington rendered most efficient aid as a collector in all departments of natural history, especially in the collection of mammals, birds, reptiles, fishes, and plants.

MAMMALS.

	No. of specimens.
Canis latrans, Say. Coyote; prairie wolf. Fort Bridger.........	2
Putorius richardsonii, Bp. Little ermine. Willow Springs, Rock Creek, and South Pass..........	3
Mephitis mephitica. Skunk. Black's Fork of Green River........	3
Taxidea americana, Waterh. Missouri badger. Pacific Springs..	2
Sciurus hudsonius, Pallas. Red squirrel; chickaree. Pacific Creek..	1
Sciurus richardsonii, Bach. Richardson's squirrel. Uinta Mountains..........	7
Pteromys alpinus, Richardson. Rocky Mountain flying squirrel. Uinta Mountains..........	1

	No. of specimens.
Tamias quadrivittatus, Rich. Missouri striped squirrel. North Platte, Pacific Springs, Little Sandy, Big Sandy, Green River, Bitter Creek, Sulphur Springs	7
Cynomys ludovicianus. Prairie Dog. Camp Reynolds	3
Cynomys gunnisonii, Baird. Short-tailed prairie dog. Big Sandy, Green River, and Fort Bridger	11
Thomomys rufescens, Maxim. Fort Union gopher. Rock Creek	1
Perognathus flavus, Baird. Pouched mouse. Green River	1
Hesperomys sonoriensis, Leconte. Sonora mouse. Fort Bridger, Uinta Mountains, Green River	7
Fiber zibethicus, Cuv. Muskrat. Rock Creek	5
Erethizon epixanthus, Brandt. Yellow-haired porcupine. North Platte, Fort Bridger, and Sulphur Springs	4
Lepus sylvaticus, Bach. Gray rabbit. Fort Bridger, Henry's Fork of Green River, Bitter Creek, Pass Creek, and Rock Creek	15
Lepus artemisia, Bach. Sage hare. North Platte, Green River, and Pine Grove	4
Lepus nuttalii, Bach. Least hare. Green River	
Lepus townsendii, Bach. Jackass rabbit. Independence Rock, on Sweetwater	
Cervus macrotis, Say. Mule deer. Henry's Fork of Green River and Red Buttes	3
Antilocapra americana, Ord. Prong-horn antelope. North Platte and Sweetwater	6
Ovis montana, Cuvier. Big Horn mountain sheep. Box Elder	3
Bison americanus, Gmelin. American buffalo. Independence Rock	1

BIRDS.

No. 1. *Hypotriorchis columbarius*, Gr. Pigeon hawk. La Bonte and Green River	6
No. 2. *Falco polyagrus*, Cassin. Prairie falcon. Laramie Peak and Uinta Mountains	4
No. 3. *Tinnunculus sparverius*, Vieill. Sparrow hawk. Bitter Cottonwood and Box Elder	4
No. 4. *Accipiter mexicanus*, Swains. Blue-backed hawk. Uinta Mountains	1
No. 5. *Accipiter fuscus*, Bonap. Sharp-shinned hawk. Uinta Mountains	1
No. 6. *Buteo swainsoni*, Bonap. Swanson's hawk. Sweetwater River	2
No. 7. *Buteo calurus*, Cassin. Black red-tailed hawk. Uinta Mountains	1
No. 8. *Buteo montanus*, Nutt. Western red-tailed hawk. Sweetwater and Fort Bridger	2
No. 9. *Circus hudsonius*, Vieill. Marsh hawk. North Platte River and Uinta Mountains	6
No. 10. *Brachyotus cassinii*, Brewer. Short-eared owl. Sweetwater River	2
No. 11. *Anthene hypugæa*, Bonap. Prairie owl. Camp Reynolds and Big Sandy River	9
No. 12. *Picus harrisii*, Aud. Harris's woodpecker. La Bonte Creek and Uinta Mountains	3
No. 13. *Picus gairdneri.* Gairdner's woodpecker. La Bonte Creek, Henry's Fork, and Green River	3

	No. of specimens.
No. 14. *Sphyropicus nuchalis*, Baird. Red-breasted woodpecker. Strawberry Creek and Uinta Mountains	6
No. 15. *Melanerpes erythrocephalus*, Sw. Red-headed woodpecker. Bitter Cottonwood and La Bonte Creek	7
No. 16. *Melanerpes torquatus*, Bonap. Lewis's woodpecker. Bitter Cottonwood Creek	1
No. 17. *Colaptes mexicanus*, Swains. Red-shafted flicker. La Bonte Creek and Fort Bridger	4
No. 18. *Colaptes hybridus*, Baird. Hybrid woodpecker. North Platte and Green River	6
No. 19. *Chordeiles henryi*, Cassin. Western night-hawk. Laramie Peak and Pacific Springs	3
No. 20. *Ceryle alcyon*, Boie. Belted kingfisher. La Bonte and and North Platte River	3
No. 21. *Tyrannus carolinensis*, Baird. King-bird; bee-bird. La Bonte and North Platte	2
No. 22. *Tyrannus verticalis*, Say. Arkansas flycatcher. Camp Reynolds and La Bonte	3
No. 23. *Sayornis sayus*, Baird. Say's flycatcher. Camp Reynolds and Sweetwater River	2
No. 24. *Contopus richardsonii*, Baird. Short-legged pewee. Bitter Cottonwood Creek	2
No. 25. *Empidonax hammondii*, Baird. Hammond's flycatcher. Pacific Springs	1
No. 26. *Turdus auduboni*, Baird. Silent thrush. Uinta Mountains	1
No. 27. *Turdus fuscesceus*, Stephens. Wilson's thrush. Green River	1
No. 28. *Turdus migratorius*, Linn. Robin. Green River and Fort Bridger	4
No. 29. *Salia arctica*, Swains. Rocky Mountain bluebird. Sweetwater, Fort Bridger, Henry's Fork of Green River, and Uinta Mountains	15
No. 30. *Regulus calendula*, Licht. Ruby-crowned kinglet. Little Sandy and Green River	12
No. 31. *Anthus ludovicianus*, Licht. Tit-lark. Henry's Fork of Green River and Uinta Mountains	2
No. 32. *Geothlypis trichas*, Cab. Maryland yellow-throat. La Bonte Creek	1
No. 33. *Geothlypis macgillivrayi*, Baird. Macgillivray's warbler. Box Elder Creek	1
No. 34. *Helminthophaga celata*, Baird. Orange-crowned warbler. Fort Bridger. Little Sandy and Green River	3
No. 35. *Dendroica audubonii*, Baird. Audubon's yellow-rumped warbler. Green River	2
No. 36. *Dendroica aestiva*, Baird. Yellow warbler. Bitter Cottonwood, La Bonte, Fort Bridger, and Green River	8
No. 37. *Myiodioctes pusillus*, Bonap. Green black-capped flycatcher. Fort Bridger and Henry's Fork of Green River	7
No. 38. *Setophaga ruticilla*, Sw. Redstart. La Bonte Creek	2
No. 39. *Hirundo lunifrons*, Say. Cliff swallow. Camp Reynolds and Bitter Creek	4
No. 40. *Progue subis*, Baird. Purple martin. Bitter Cottonwood Creek	2

	No. of specimens.
No. 41. *Myiadestes townsendii*, Cab. Townsend's flycatcher. Green River	3
No. 42. *Collyrio borealis*, Baird. Great northern shrike. Green River and Rock Creek	3
No. 43. *Collyrio excubitoroides*, Baird. White-rumped shrike. La Bonte Creek	2
No. 44. *Vireosylvia swainsonii*, Baird. Western warbling flycatcher. Green River	1
No. 45. *Galeoscoptes carolinensis*, Cab. Cat-bird. La Bonte Creek	2
No. 46. *Oreoscoptes montanus*, mountain mocking-bird. La Bonte Creek, North Platte, Pacific Creek, Green River, Fort Bridger, and Henry's Fork of Green River	10
No. 47. *Harporhynchus longicauda*, Baird. Long-tailed thrush. Bitter Cottonwood	1
No. 48. *Salpinctus obsoletus*, Cab. Rock wren. Sweetwater River.	1
No. 49. *Troglodytes parkmannii*, Aud. Parkman's wren. Green River	2
No. 50. *Sitta canadensis*, Linn. Red-bellied nut-hatch. Green River, Fort Bridger, Henry's Fork, and Sulphur Springs	5
No. 51. *Parus septentrionalis*, Harris. Long-tailed chicadee. Bitter Cottonwood Creek, Fort Bridger, Green River, and Bitter Creek	11
No. 52. *Parus montanus*, Gambel. Mountain titmouse. Uinta Mountains	2
No. 53. *Psaltriparus plumbeus*, Baird. Lead-colored tit. Green River	3
No. 54. *Eremophila cornuta*, Boie. Sky-lark. North Platte, Henry's Fork of Green River, Uinta Mountains, Green River, Pine Grove, and Little Laramie	42
No. 55. *Pinicola canadensis*, Cab. Rine grosbeak. Uinta Mountains	1
No. 56. *Chrysomitris tristis*, Bonap. Yellow-bird. Green River	5
No. 57. *Curvirostra mexicana*, Strick. Mexican cross-bill. Bitter Cottonwood, La Bonte, and Green River	3
No. 58. *Curvirostra leucoptera*, Wils. White-winged cross-bill. Box Elder Creek	1
No. 59. *Aegiothus linaria*, Cab. Lesser red poll. Camp Reynolds, Green River, Rock Creek, Sulphur Springs, and Laramie River	12
No. 60. *Leucosticte tephrocotis*, Sw. Gray-crowned finch. Uinta Mountains	1
No. 61. *Plectrophanes maccownii*, Lawr. Maccown's long-spur. Camp Reynolds	1
No. 62. *Passerculus alaudinus*, Bonap. Lark sparrow. Bitter Cottonwood Creek, Strawberry Creek, Green River, and Big Sandy	6
No. 63. *Pooecetes gramineus*, Baird. Grass finch. Bitter Cottonwood, Pacific Springs, Big Sandy, Little Sandy, Fort Bridger, and Uinta Mountains	25
No. 64. *Chondestes grammaca*, Bonap. Lark finch. Bitter Cottonwood Creek	1
No. 65. *Zonotrichia leucophrys*, Sw. White-crowned sparrow. Pacific Springs, Green River, and Fort Bridger	4
No. 66. *Zonotrihia gambelii*, Gambel. Gambel's finch. Fort Bridger, Henry's Fork of Green River, Uinta Mountains, and Rock Creek	40
No. 67. *Junco oregonus*, Sclat. Oregon snow-bird. Henry's Fork of Green River, Green River, and Rock Creek	6

	No. of specimens.
No. 68. *Poospiza belli*, Sclat. Bell's finch. Henry's Fork of Green River, Green River, and Rock Creek	5
No. 69. *Spizella monticola*, Baird. Tree sparrow. Green River, Henry's Fork, and Rock Creek	4
No. 70. *Spizella socialis*, Bonap. Chipping sparrow. Little Sandy and Green River	2
No. 71. *Spizella brewerii*, Cass. Brewer's sparrow. Little Sandy and Green River	10
No. 72. *Melospiza fallax*, Baird. Mountain song sparrow. Green River and Henry's Fork of Green River	28
No. 73. *Melospiza linconii*, Baird. Lincoln's finch. Head of Henry's Fork and Green River	6
No. 74. *Calamospiza bicolor*, Bonap. Lark bunting. Camp Reynolds and Bitter Cottonwood Creek	5
No. 75. *Pipilo arcticus*, Sw. Arctic tower. Fort Sanders	4
No. 76. *Pipilo chlorura*, Baird. Green-tailed finch. Little Sandy and Green River	3
No. 77. *Molothrus pecoris*, Sw. Cow-bird. La Bonte Creek	1
No. 78. *Agelaius phœniceus*, Vieill. Red-winged blackbird. Camp Stevenson, on Henry's Fork of Green River	2
No. 79. *Xanthocephalus icterocephalus*. Yellow-headed blackbird. Green River	1
No. 80. *Sturnella neglecta*, Aud. Western lark. Camp Reynolds, Fort Fetterman, Fort Bridger, and Green River	24
No. 81 *Scolecophagus cyanocephalus*. Brewer's blackbird. Camp Reynolds, Fort Fetterman, and Sweetwater	27
No. 82. *Corvus carnivorus*, Bartram. American raven. Camp Reynolds	1
No. 83. *Corvus americanus*, Aud. Common crow. La Bonte Creek	1
No. 84. *Picicorvus columbianus*. Clark's crow. Pacific Springs and Pacific Creek	3
No. 85. *Pica hudsonica*, Bonap. Magpie. Camp Reynolds, North Platte River, Sweetwater River, Green River, and Fort Bridger	13
No. 86. *Cyanura macrolopha*, Baird. Long-crested jay. Green River	1
No. 87. *Cyanocitta Woodhousei*, Baird. Woodhouse's jay. Green River	1
No. 88. *Perisoreus canadensis*, Bonap. Canada jay. Henry's Fork and Green River	8
No. 89. *Zenaidura carolinensis*, Bonap. Common dove. Fort Bridger	4
No. 90. *Tetrao-obscurus*, Say. Dusky grouse. Uinta Mountains	6
No. 91. *Centrocercus urophasianus*, Sw. Sage cock. Sweetwater, Green River, and Plains	
No. 92. *Pediocœtes columbianus*, (Ord.) Elliot. Sharp-tailed grouse. La Bonte Creek	1
No. 93. *Bonasa umbelloides*, Baird. Gray mountain grouse. Camp Jackson, Uinta Mountains	3
No. 94. *Lagopus leucurus*, Swains. White-tailed ptarmigan. Burthoud's Pass, Rocky Mountains	1
No. 95. *Botaurus lentiginosus*, Stephens. Bittern; stake driver. Camp Leidy, on Sweetwater River	1
No. 96. *Charadrius virginicus*, Borck. Golden plover. Camp Dawes, on Rock Creek	3

	No. of specimens.
No. 97. *Aegialitis vociferus*, Cassin. Kill-deer. Camp Reynolds	7
No. 98. *Recurvirostra americana*, Gm. American avoset. Camp Baird, on North Platte River	1
No. 99. *Phalaropus wilsonii*, Sab. Wilson's phalarope. Camp Reynolds	1
No. 100. *Phalaropus hyperboreus*, Temm. Northern phalarope. Big Sandy River	1
No. 101. *Gallinago wilsonii*, Bonap. English snipe. Fort Sanders.	1
No. 102. *Actodromus minutilla*, Coues. Least sandpiper. Camp Baird, on North Platte, and Little Sandy	2
No. 103. *Actodromus bairdii*, Coues. Baird's sandpiper. North Platte and Little Sandy	3
No. 104. *Ereunetes pusillus*, Coues. Semi-palmated sandpiper. North Platte River	1
No. 105. *Micropalama himantopus*, Baird. Stilt sandpiper. Fort Bridger	1
No. 106. *Gambetta melanoleuca*, Bonap. Tell-tale; stone snipe. Camp Reynolds and Fort Fetterman	14
No. 107. *Gambetta flavipes*, Bonap. Yellow legs. Camp Reynolds and Camp Logan, near Church Buttes	8
No. 108. *Rhyacophilus solitarius*, Bonap. Solitary sandpiper. Camp Reynolds and Fort Fetterman	6
No. 109. *Tringoides macularius*, Gray. Spotted sandpiper. Fort Fetterman and Camp Gifford, on Sweetwater River	3
No 110. *Fulica americana*, Gmelin. Coot. Camp Baird, on North Platte River	1
No. 111. *Bernicla canadensis*, Boie. Canada goose. Camp Gifford, on Sweetwater River	2
No. 112. *Anas boschas*, Linn. Mallard. North Platte River and Sweetwater	7
No. 113. *Dafila acuta*, Jenyns. Sprig-tail pin-tail. Rock Creek	1
No. 114. *Nettion carolinensis*, Baird. Green-winged teal. Green River and Fort Sanders	13
No. 115. *Querquedula cyanoptera*, Cassin. Red-breasted teal. Sweetwater and North Platte	4
No. 116. *Spatula clypeata*, Boie. Shoveler. Sweetwater and Fort Bridger	3
No. 117. *Mareca americana*, Stevens. Bald pate. Pass Creek	1
No. 118. *Fulix collaris*, Baird. Ring-necked duck. Green River	2
No. 119. *Bucephala albeola*, Baird. Butter-ball. Fort Sanders	1
No. 120. *Erismatura rubida*, Bonap. Ruddy duck. Pacific Creek.	1
No. 121. *Mergus americanus*, Cass. Shelldrake. Sweetwater River and Fort Bridger	3
No. 122. *Lophodytes cucullatus*, Reich. Hooded merganser. Green River	1
No. 124. *Podiceps californicus*, Heerman. California grebe. North Platte River	1

II.—REPORT ON MOLLUSCA.

By S. R. Roberts,

Recorder Conchological Section, Academy Natural Sciences, Philadelphia.

The following list comprises the mollusca collected by Professor F. V. Hayden while engaged in the various geological surveys made under direction of the Department of the Interior. An examination of this list will show that most of the species named are common not only to the districts watered by the Ohio and Mississippi Rivers, but also to many other sections of the North and East, thus showing a widespread distribution of nearly all the species which are abundant in the more eastern portions of the United States. This is the more curious, particularly among the fluviatile mollusks of the Upper Missouri, for there the rivers belong to a different system of drainage.

Of the land shells the species *Helix haydeni*, Binney, which was collected in large numbers at Weber Cañon, Utah, is interesting from the fact that it belongs to an entirely different sub-genus from any previously known to this country, it being very closely allied to the Madeira genus, *Tectula*, Lowe.

Dr. Hayden collected more than fifty specimens of different ages, all of which were somewhat bleached.

This species was found associated with *Helix cooperi*, Binney, many specimens of the latter being also obtained.

At Falls City, Nebraska, a small shell was found near the size of *Helix bucculenta*, Gould, but with a closed umbilicus. It is probably a small variety of *H. albolabris*, Say, and has been so labeled in the collection of the Philadelphia Academy of Natural Sciences, where the specimens are deposited.

Among the fresh-water shells only one species of the family *Viviparidæ*, the *Melantho integra*, Say, has been noticed. This was collected in the Big Sioux River, Nebraska.

Pomatiopsis lapidaria, Say, belonging to the *Amnicolidæ*, was found at Fort Berthold, in Nebraska. This is the most western locality known for the species.

In addition to the number of species belonging to the family *Unionidæ*, common to the Northern and Western States, there will be noticed three southern species which were collected at Falls City, Nebraska. These are *Unio nigerrimus*, Lea, *U. Rutersvillensis*, Lea, both belonging to the Texan fauna, and the *Unio Mississippiensis*, Conrad, which was described from specimens obtained in Mississippi. *Unio Topekæensis*, Lea, a Kansas species, was also found here, while at Nebraska City a perfect valve of *Unio pressus*, Lea, was obtained. This species belongs to the great lakes, sometimes occurring as far east as the Erie Canal, New York.

The fact of there being no *Melanians* in the list confirms the statement made by George W. Tryon, jr., in his monograph of the *Strepomatidæ* (in the Amer. Jour. Conch., vol. 1, p. 125,) that these shells do not occur west of the Mississippi River, except in the rivers of the Pacific States.

The list of species is not as complete as might have been expected, but future explorations will no doubt bring to notice many additional forms which are to be found in more eastern localities.

LAND SHELLS.

HELICIDÆ.

Helix alternata, Say.
albolabris, Say.
albolabris, var.?
concava, Say.
costata, Müll.
chersina, Say.
cooperi, W. G. B.
elevata, Say.
electrina, Gould.
fuliginosa, Binn.
fallax, Say.
haydeni, W. G. B.
hirsuta, Say.
inflecta, Say.
indentata, Say.
ligera, Say.
lineata, Say.
minuscula, Binn.
minuta, Say.
monodon, Rack.
multilineata, Say.
profunda, Say.

HELICIDÆ—Continued.

Helix solitaria, Say.
striatella, Anth.
thyroides, Say.
tridentata, Say.

PUPADÆ.

Pupa armifera, Say.
badia, Adams.
blandi, W. G. B.
modesta, Say.
pentodon, Say.
Zua subcylindracea, Chem.

SUCCINIDÆ.

Succinea avara, Say.
haydeni, W. G. B.
lineata, W. G. B.
nuttalliana, ? Lea.
obliqua, Say.
vermeta, Say.

FRESH-WATER SHELLS.

Univalves.

VIVIPARIDÆ.

Melantho integra, Say.

AMNICOLIDÆ.

Amnicola porata, Say.
cincinnatiensis, Anth.
Pomatiopsis lapidaria, Say.

LYMNÆADÆ.

Lymnea desidiosa, Say.
elodes, Say.
haydeni, Lea.
humilis, Lea.
kirtlandiana, Lea.
palustris, Müll.

LYMNÆADÆ—Continued.

Lymnea reflexa, Say.
umbrosa, Say.

PHYSADÆ.

Physa heterostropha, Say.
Bulinus hypnorum, Linn.

PLANORBIDÆ.

Planorbis bicarinatus, Say.
trivolvis, Say,
companulatus, Say.
parvus, Say.
lentus, Say.

Bivalves.

UNIONIDÆ.

Unio anodontoides, Lea.
alatus, Say.
asperrimus, Say.
elegans, Lea.
gibbosus, Barnes.
latecostatus, Lea.
lævissimus, Lea.
luteolus, Lam.
mississippiensis, Conrad.
nigerrimus, Lea.
parvus, Barnes.
pressus, Lea.
rectus, Lam.
rubiginosus, Lea.

UNIONIDÆ—Continued.

Unio rutersvillensis, Lea.
topekænsis, Lea.
ventricosus, Barnes.
zig-zag, Lea.
Margaritana complanata, Say.
Anodonta footiana, Lea.
ferussaciana, Lea.
undulata, Say.

CORBICULADÆ.

Sphærium sulcatum, Lam.
striatinum, ? Lam.
Pisidium abditum, ? Hald.

III.—COLEOPTERA.

A LIST OF COLEOPTERA COLLECTED BY C. THOMAS, IN EASTERN COLORADO AND NORTHEASTERN NEW MEXICO, DURING THE SURVEY OF 1869.

BY DR. G. H. HORN.

Cicindela formosa, Say.
obsoleta, Say.
pulchra, Say.
vulgaris, Say.
repanda, Dcj.
punctulata, Fabr.
Nebria bivittata.
Calosoma luxatum, Say.
Carabus serratus, Say.
Pasimachus elongatus, Lec.
validus, Lec.
Lebia viridis, Say.
Platynus extensicollis, Lec.
Pterostichus protractus, Lec.
Amara obesa, Say.
Cratognathus setosus, Lec.
Chlænius sericeus, Say.
Nothopus zabroides, Lec.
Cratacanthus dubius, Lec.
Harpalus caliginosus, Say.
pennsylvanicus, Lec.
compar, Lec.
obesulus.
amputatus, Say.
Hydrophilus triangularis, Say.
Necrophorus hecate.
marginatus, Fabr.
Eleodes fusiformis.
extricata.
Embaphion planum.
Corphyra collaris.
Mordellistena æmula.
Meloe sublævis.
Epicauta corvina.
maculata.
ferruginea.
Lytta sphæricollis.
nuttallii.
viridana.
Nemognatha lutea.
Erotylus Boisduvalii.
Sphenophorus. ?
Baridius. ?
Lepyrus colon.
Rhynchites bicolor.
Prionus californicus.
Parandra ferruginea.
Crosidius discordeus.
Criocephalus productus.
Asenum atuem.
Tetropium cinnamopterum.
Moneilema annulatum.
Monohammus scutellaris.
Acmeops striglata.

Silpha ramosa, Say.
lapponica, Herbst.
Phalacrus pencillatus, Say.
Carpophilus pallipes.
Dermestes marmoratus, Say.
Canthon lævis, Drury.
praticola, Lec.
Phanæus carnifex, McLeay.
Serica vespertina, Lec.
Tostegoptera lanceolata.
Polyphylla 10-lineata, Say.
Euryomia kernii, Lec.
Melanophila longipes, Gory.
drummondii, Lac.
Monocrepidius auritus, Germ.
Photinus ingricans, Lac.
Chauliognathus basalis, Lec.
Collops 4-maculatus, Er.
tricolor, Say.
Trichodes ornatus, Say.
Hydnocera subunca, Spin.
Epitrayus canaliculatus, Say.
Pelecyphorus serratus, Sec.
sordidus, Lec.
Asida opaca, Say.
convexa, Lec.
Eusattus convexus, Lec.
Coniontis obesa.
Eleodes tricosta.
carbonaria.
hispilabris.
obscura.
suturalis.
longicollis.
obsoleta.
Galeruca americana.
externa.
Diabrotica vittata.
tricineta.
Doryphora 10-lineata.
Graptodera bimarginata.
Disonycha alternata.
collaris.
Blepharida rhois.
Chrysomela exclamationis.
verrucosa.
punctipunctata.
flavomarginata.
adonidis.
Chrysochus auratus.
Coscinoptera axillaris.
franciscana.
Pachybrachis athomus.
Cryptocephalus viduatus.
4-guttatus.
vitticollis.
confluens.
Hippodamia Lecontii.
5-signata.
convergens.
Coccinella transversoguttata.
9-notata.
monticola.
Brachyacantha ursina.
Dendroctomus tenebrionoides.
Anisosticta vittigera.
Monaxia debilis.
Raphidopalpus atripennes.
Typocerus sumatrus.

IV.—HEMIPTERA.

A LIST OF HEMIPTERA COLLECTED IN EASTERN COLORADO AND NORTHEASTERN NEW MEXICO, BY C. THOMAS, DURING THE EXPEDITION OF 1869.

BY P. R. UHLER, ESQ.

HETEROPTERA.

CORIMELÆNIDÆ.

Corimelæna nitiduloides, Wolff.

PACHYCORIDÆ.

Homæmus bijugis, Uhl.

HALYDIDÆ.

Brochymena annulata, Fab.

PENTATOMIDÆ.

Perillus claudus, Say.
exaptus, Say.
Neottiglossa undata, Say.
Euschistus punctipes, Say.
Murgantia histrionica, Hahn.
Pentatoma custator, Fab.
graminicolor, Uhl.
Cimex platychilus, Uhl.

COREIDÆ.

Piezogaster alternatus, Say.
Merocoris distinctus, Dallas.
Dasycoris pilicornis, H. Schf.
Margus inconspicuus, Uhl.
Catorhintha guttula, Fab.
Neides decurvatus, Uhl.
Alydus ater, Dallas.
Protenor Belfragei, Hagl.
Leptocoris trivittatus, Say.
Harmostes reflexulus, Say.
Corizus borealis, Uhl.
viridicatus, Uhl.
lateralis, Say.

LYGÆIDÆ.

Lygæus reclivatus, Say.
circumlitus, Stal.
admirabilis, Uhl.
Nysius californicus, Stal.
angustatus, Uhl.
Ophthalmicus piceus, Say.
Pamera fallax, Say.
Cymbogaster diffusus, Uhl.
Araphe carolina, H. Schf.

LARGIDÆ.

Largus succinctus, Fab.

PHYTOCORIDÆ.

Miris debilis, Uhl.
ruficornis, H. Schf.
rubicundus, Uhl.
Calocoris rapidus, Say.
Resthenia eremicola, Uhl.
confraterna, Uhl.
Lopidea media, Say.
Lygus annexus, Uhl.
diffusus, Uhl.
redimitus, Uhl.
Phytocoris, nov. sp.
Oncotylus militaris, Uhl.
Cyllecoris, nov. sp.
Dacota hesperia, Uhl.
Capsus delicatulus, Uhl.
nov. sp.
Stiphrosoma stygica, Say.
Labops hesperius, Uhl.
Stictocephalus inermis, Uhl.
Rhopalotomus pacificus, Uhl.
Charagochilus venaticus, Uhl.
Tinicephalus simplex, Uhl.
Phylus angustatus, Uhl.

ARADIDÆ.

Aradus rectus, Say.

PHYMATIDÆ.

Phymata erosa, Fab.

REDUVIDÆ.

Nabis inscriptus, Kirby.
subcoleoptratus, Kirby.
Sinea multispinosa, Geer.
Herega spissipes, Say.
Diplodus luridus, Stal.

HYDROMETRÆ.

Hygrotrechus remigis, Say.

NEPÆ.

Nepa 4-dentata, Stal.

HOMOPTERA.

FULGORIDÆ.

Scolops sulcipes, Say.
hesperius, Uhl.

CIXIIDÆ.

Cixius stigmatus, Say.
Bruchomorpha ocellata, Newm.

CICADÆ.

Cicada dorsata, Say.
canicularis, Harris.
hesperia, Uhl.
synodica, Say.

MEMBRACIDÆ.

Ceresa diceros, Say.
Smilia, nov. sp.
Entilia modesta, Uhl.

CERCOPIDÆ.

Aphrophora permutata, Uhl.
quadrangularis, Say.
Ptyelus lineatus, Fab.

TETTIGONIDÆ.

Gypona reverta, Uhl.
Proconia costalis, Fab.
Helochara communis, Fab.

V.—CATALOGUE OF PLANTS.

BY THOMAS C. PORTER,

Lafayette College, Easton, Pennsylvania.

This catalogue embraces the plants collected in Wyoming Territory, by Dr. F. V. Hayden, during the geological survey of 1870—at Camp Carlin, from July 25 to 30, on the route from Fort D. A. Russell, via Fort Fetterman, Sweetwater, South Pass, Wind River Mountains, and Green River, to Fort Bridger, from August 1 to September 13; in the Uinta Mountains, south of Henry's Fork of Green River, in the latter half of September, and on Henry's Fork, in the month of October. To these are added his collection in the North Park, Colorado Territory, August, 1868, and another, made by Mr. B. H. Smith, in the region around the city of Denver, during the summer of 1869.

RANUNCULACEÆ.

Atragene alpina, L. (*A. Ochotensis*, Pallas.)—Mountains near Denver

Clematis ligusticifolia, Nutt.—Mountains near Denver, Colorado Territory; August to September.

Anemone multifida, DC.—Mountains near Denver; Uinta Mountains.

Anemone Pennsylvanica, L.—Fossil beds near Denver.

Anemone patens, L., var. *Nuttalliana*, Gray.—Denver.

Thalictrum sparsiflorum, Turcz.—Mountains near Denver; Uinta Mountains. In fruit.

Ranunculus divaricatus, Schrank.—Denver.

Ranunculus Cymbalaria, Pursh.—Denver, Colorado Territory; August to September.

Ranunculus affinis, R. Br.—Near Denver.

Ranunculus sceleratus, L.—Denver.

Ranunculus Pennsylvanicus, L.—Near Denver.

Ranunculus repens, L.—Near Denver.

Aquilegia cœrulea, Torr.—Uinta Mountains. In fruit.

Trollius laxus, Salisb—Wyoming Territory; August to September. In fruit.

Delphinium azureum, Michx.—Denver; Camp Carlin, Wyoming Territory.

Delphinium elatum, L.—Mountains near Denver.

PAPAVERACEÆ.

Argemone Mexicana, L.—Denver; Camp Carlin, Wyoming Territory.

FUMARIACEÆ.

Corydalis aurea, Willd.—Near Denver.

CRUCIFERÆ.

Nasturtium sinuatum, Nutt.—Near Denver.

Nasturtium obtusum, Nutt.—Henry's Fork of Green River.

Arabis lyrata, L.—Near Denver.

Arabis hirsuta, Scop.—Near Denver.

Streptanthus linearifolius, Gray.—Camp Carlin, Wyoming Territory.

Cardamine paucisecta, Benth.—Henry's Fork of Green River.

Erysimum asperum, DC.—Denver.

Draba aurea, Vahl.—Near Denver.

Draba nivalis, Willd.—(*D. rupestris*, R. Br., var. "*siliculis glabris*," Hook. Fl. Bor. Am., 1, p. 53.)—Uinta Mountains.

Vesicaria Ludoviciana, DC.—Near Denver.

Physaria didymocarpa, Gray.—Near Denver.

Lepidium ruderale, L.—Gray, Pl. Wright, 2, p. 15.—Denver.

Lepidium sativum, L.—Near Denver. Probably introduced.

Thlaspi Fendleri, Gray.—Uinta Mountains, Wyoming Territory.

CAPPARIDACEÆ.

Cleome integrifolia, Torr. and Gray.—Denver; Camp Carlin, Wyoming Territory.

Polanisia trachysperma, Gray.—Wyoming Territory; August to September.

CARYOPHYLLACEÆ.

Silene acaulis, L.—Mountains near Denver.

Lychnis apetala, L., var. *pauciflora*, DC.—Uinta Mountains.

Arenaria congesta, Torr. and Gray.—North Park, Colorado Territory; Uinta Mountains, Wyoming Territory.

Arenaria Fendleri, Gray, (Pl. Fendler., p. 13).—Denver.

Arenaria arctica, Stevenson.—Mountains near Denver; Uinta Mountains.

Arenaria Rossii, R. Br.—Henry's Fork of Green River.

Arenaria verna, L.?—Uinta Mountains, Wyoming Territory. In fruit only, with old capsules which have shed their seed.

Stellaria borealis, Bigelow.—Henry's Fork of Green River.

Cerastium arvense, L.—Near Denver.

Paronychia sessiliflora, Nutt.—Camp Carlin, Wyoming Territory.

Paronychia Jamesii, Torr. and Gray.—Near Denver.

MALVACEÆ.

Malvastrum coccineum, Gray.—Denver; Camp Carlin, Wyoming Territory.

Sidalcea malvæflora, Gray.—North Park, Colorado Territory; Uinta Mountains.

Sphæralcea acerifolia, Nutt. (*Malva rivularis*, Dougl.)—Wyoming Territory; August to September.

LINACEÆ.

Linum perenne, L.—North Park, Colorado Territory; Uinta Mountains.

Linum Kingii, Watson ined. (in Clarence King's Report,) var. *sedoides.*—Uinta Mountains, September 25, 1870. Very glabrous, low, much branched from the base; the short, angled stems 4 to 6 inches high; leaves numerous, 3 to 4 lines in length, pale green, linear-oblong, obtuse, thickish and crowded, especially on the younger stems, giving the plant the aspect of a *Sedum*. Stipular glands conspicuous, persistent. Panicles contracted, corymbose; sepals broadly ovate, glandular-ciliate, shorter than the globose 10-valved capsule. Styles 5, distinct. Capsules about 1½ lines in diameter, the secondary dissepiments incomplete and fibrous-pilose on the margin. In fruit only, but a flowering specimen of Watson's plant has golden-yellow obovate petals, half an inch in length.

GERANIACEÆ.

Geranium Frémontii, Torr.—Denver; Camp Carlin, Wyoming Territory.

Geranium Richardsonii, Fisch. and Meyer.—Wyoming Territory; August to September. In fruit.

OXALIDACEÆ.

Oxalis stricta, L.—Near Denver.

VITACEÆ.

Vitis riparia, Michx.—Wyoming Territory; August to September. In fruit.

RHAMNACEÆ.

Ceanothus ovalis, Bigelow.—Near Denver.

Ceanothus velutinus, Dougl., var. *lævigatus*, Torr. and Gr., Fl. N. Am., 1, p. 686.—Henry's Fork of Green River.

CELASTRACEÆ.

Pachystima Myrsinitis, Raf.—Henry's Fork of Green River.

ACERACEÆ.

Acer glabrum, Torr.—Denver; Henry's Fork of Green River.

Negundo aceroides, Manch.—Near Denver.

LEGUMINOSÆ.

Lupinus ornatus, Dougl.—Near Denver.

Lupinus parviflorus, Nutt.—Uinta Mountains.

Lupinus pusillus, Pursh.—Near Denver.

Lupinus decumbens, Torr.—Wyoming Territory; August to September.

Trifolium Parryi, Gray.—Uinta Mountains, Wyoming Territory.

Psoralea floribunda, Nutt.—Denver.

Psoralea lanceolata, Pursh.—Near Denver.

Petalostemon violaceus, Michx.—Near Denver.

Petalostemon candidus, Michx.—Wyoming Territory; August to September.

Hosackia Purshiana, Benth.—North Park, Colorado Territory.

Astragalus Hypoglottis, L.—Camp Carlin, Wyoming Territory.

Astragalus adsurgens, Nutt.—Wyoming Territory; August to September.

Astragalus flexuosus, Dougl.—Near Denver.

Astragalus Kentrophyta, Gray.—Near Denver.

Oxytropis Lamberti, Pursh.—Near Denver.

Oxytropis deflexa, DC.—Wyoming Territory; August to September.

Glycyrrhiza lepidota, Nutt.—Henry's Fork of Green River.

Vicia Americana, Muhl.—Near Denver.

Lathyrus palustris, L.—Henry's Fork of Green River.

Lathyrus linearis, Nutt.—Near Denver.

Sophora sericea, Nutt.—Near Denver.

Thermopsis rhombifolia, Nutt.—Near Denver.

Thermopsis fabacea, Hook., var. *montana*, Gray.—Wyoming Territory; August to September.

ROSACEÆ.

Prunus Virginiana, L.—Near Denver.

Spiræa opulifolia, L.—Near Denver.

Spiræa dumosa, Nutt.—Turkey Creek, Colorado Territory; Wyoming Territory; August to September.

Spiræa cæspitosa, Nutt.—Henry's Fork of Green River.

Cercocarpus parvifolius, Nutt.—Near Denver.

Geum Rossii, Seringe, var. B. Torr. and Gr.—Uinta Mountains.

Geum triflorum, Pursh.—Denver; North Park, Colorado Territory.

Sibbaldia procumbers, L.—Uinta Mountains.

Ivesia Gordoni, Torr. and Gray; Gray in Proc. Am. Acad., 6, p. 530.—Uinta Mountains, September 25, 1870.—Differs from the typical form in having a single carpel! The small spatulate petals appear white, but are probably faded.

Potentilla Norvegica, L.—Denver; Camp Carlin, Wyoming Territory.

Potentilla fastigiata, Nutt.—Wyoming Territory; August to September.

Potentilla nivea, L.—Denver; Uinta Mountains.

Potentilla Pennsylvanica, L., var. *Hippiana*, Torr. and Gr.—Denver.

Potentilla arguta, Pursh.—Wyoming Territory; August to September.

Potentilla Anserina, L.—Henry's Fork of Green River.

Potentilla fruticosa, L.—Denver; North Park; Uinta Mountains.

Rubus strigosus, Michx.—Wyoming Territory; August to September.

Rosa gymnocarpa, Nutt.—Henry's Fork of Green River. In fruit.

Rosa blanda, Ait.—Denver; Wyoming Territory; August to September.

Pyrus sambucifolia, Ch. and Schl.—Henry's Fork of Green River. In fruit.

SAXIFRAGACEÆ.

Jamesia Americana, Torr. & Gray.—Denver; North Park, Colorado Territory.

Saxifraga bronchialis, L.—Mountains near Denver.

Heuchera bracteata, Seringe.—Fall River, Colorado Territory; B. H. Smith.

Heuchera parvifolia, Nutt.—Fall River, Colorado Territory; B. H. Smith.

CRASSULACEÆ.

Sedum stenopetalum, Pursh.—Fall River, Colorado Territory; Uinta Mountains.

Sedum rhodanthum, Gray.—Uinta Mountains.

Sedum Rhodiola, DC.—Mountains near Denver.

ONAGRACEÆ.

Gaura parviflora, Dougl.—Near Denver.
Gaura coccinea, Nutt.—Near Denver.
Epilobium augustifolium, L. Denver; Uinta Mountains.
Epilobium paniculatum, Nutt.—Near Denver.
Epilobium coloratum, Muhl.—Denver; Wyoming Territory; August to September.
Œnothera biennis, L.—Denver; Wyoming Territory; August to September.
Œnothera pinnatifida, Nutt.—Near Denver.
Œnothera coronopifolia, Torr. and Gray.—Near Denver.
Œnothera albicaulis, Nutt.—Denver; Camp Carlin, Wyoming Territory.
Œnothera cæspitosa, Nutt.—North Park, Colorado Territory.
Œnothera serrulata, Nutt.—Denver; Wyoming Territory; August to September.

LOASACEÆ.

Mentzelia ornata, Torr. and Gray.—Wyoming Territory; August to September.
Mentzelia nuda, Torr. and Gray.—Denver; Camp Carlin, Wyoming Territory.

UMBELLIFERÆ.

Archangelica Gmelini, DC.—Uinta Mountains.
Cicuta maculata, L.—Wyoming Territory; August to September.
Carum Gairdneri, Gray. Proc. Am. Acad., 7, p. 344. (*Edosmia Gairdneri*, Torr. & Gr., Fl. N. Am., 1, p. 612.)—Uinta Mountains; Wyoming Territory; August to September.

CORNACEÆ.

Cornus stolonifera, Michx.—Denver; Henry's Fork of Green River.

CAPRIFOLIACEÆ.

Symphoricarpus occidentalis, R. Br.—Denver; Henry's Fork of Green River.
Lonicera involucrata, Banks.—Henry's Fork of Green River.

RUBIACEÆ.

Galium boreale, L.—Denver; Uinta Mountains.

VALERIANACEÆ.

Valeriana dioica, L., var. *sylvatica*, Richards.—Denver.
Valeriana edulis, Nutt.—Uinta Mountains.

COMPOSITÆ.

Liatris punctata, Hook.—North Park, Colorado Territory; Wyoming Territory.
Brickellia grandiflora, Nutt.—Near Denver.
Machæranthera tanacetifolia, Nees.—Denver.
Aster falcatus, Lindl.—North Park, Colorado Territory; 1868.
Aster ericoides, L.—Near Denver.
Aster lævis, L.—Wyoming Territory; August to September.
Aster adscendens, Lindl., var. *ciliatifolius*, Torr. and Gray.—Camp Carlin, Wyoming Territory; Henry's Fork of Green River.
Aster multiflorus, Ait.—North Fork, Colorado Territory; Henry's Fork of Green River.

Aster Fendleri, Gray.—Uinta Mountains, Wyoming Territory.

Aster glaucus, Torr. and Gray.—Uinta Mountains, Wyoming Territory.

Aster salsuginosus, Richards.—Uinta Mountains.

Aster glacialis, Nutt.—Uinta Mountains.

Aster angustus, Torr. and Gray.—Uinta Mountains.

Erigeron compositum, Pursh.—Near Denver.

Erigeron divergens, Torr. and Gray.—Denver.

Erigeron glabellum, Nutt.—Mountains near Denver.

Erigeron Canadense, L.—Denver.

Solidago Virga-aurea, L., var. *multiradiata*, Torr. and Gray.

Solidago rigida, L.—Denver; Wyoming Territory.

Solidago memoralis, Ait., var.—Denver.

Solidago Canadensis, L., var. *Scabra*, Torr. and Gray.—Camp Carlin; Henry's Fork of Green River.

Solidago gigantea, Ait.—Near Denver.

Gutierrezia Euthamiæ, Torr. and Gray.—Near Denver.

Linosyris graveolens, Torr. and Gray.—North Park, Colorado Territory; Henry's Fork of Green River, Wyoming Territory.

Linosyris viscidiflora, Hook.—Denver; North Park, Colorado Territory; Wyoming Territory; August to September.

Linosyris lanceolata, Torr. and Gray.—North Park, Colorado Territory.

Aplopappus spinulosus, DC.—Denver; North Park, Colorado Territory.

Aplopappus Parryi, Gray.—Mountains near Denver.

Grindelia squarrosa, Dunal.—Denver; North Park, Colorado Territory; Camp Carlin, Wyoming Territory.

Chrysopsis villosa, Nutt.—Denver; Camp Carlin, Wyoming Territory.

Chrysopsis hispida, Hook.—Near Denver.

Euphrosyne xanthiifolia, Gray. (*Cyclachæna xanthiifolia*, Fres.; Torr. & Gray, Fl. N. Am., 2. p. 286.)—Camp Carlin, Wyoming Territory.

Ambrosia trifida, L.—Wyoming Territory, August to September.

Rudbeckia laciniata, L.—Near Denver.

Rudbeckia hirta, L.—Denver; Camp Carlin, Wyoming Territory.

Lepachys columnaris, Torr. and Gray.—Wyoming Territory; August to September.

Helianthus petiolaris, Nutt.—Denver; Camp Carlin, Wyoming Territory.

Helianthus rigidus, Desf.—Wyoming Territory; August to September.

Helianthus strumosus, L. var.—Camp Carlin, Wyoming Territory.

Helianthus lætiflorus, Pers.—Camp Carlin, Wyoming Territory.

Helianthella uniflora, Torr. and Gray.—Near Denver.

Thelesperma fiilifolium, Gray.—Near Denver.

Gaillardia aristata, Pursh.—Denver; North Park, Colorado Territory; Wyoming Territory; August to September.

Villanova chrysanthemoides, Gray.—Denver.

Chaenactis achilleæfolia, Hook and Arn.—Denver.

Bahia oppositifolia, Torr. and Gray.—Camp Carlin, Wyoming Territory.

Helenium autumnale, L.—Wyoming Territory; August to September.

Achillea Millefolium, L.—Wyoming Territory; August to September.

Artemisia canadensis, Michx.—Denver; Wyoming Territory; August to September.

Artemisia tridentata, Nutt.—Denver; Wyoming Territory; August to September.

Artemisia cana, Pursh.—Henry's Fork of Green River.

Artemisia trifida, Nutt.—Henry's Fork of Green River.

Artemisia Ludoviciana, Nutt, var. *gnaphalodes*, Torr. and Gray.—Henry's Fork of Green River; Wyoming Territory; August to September.

Artemisia Richardsoniana, Bess.—Uinta Mountains.

Artemisia frigida, Willd.—Denver; North Park, Colorado Territory; Wyoming Territory; August to September.

Gnaphalium Sprengelii, Hook and Arn.—Denver.

Antennaria dioica, Gaertn.—Denver; Uinta Mountains.

Antennaria alpina, Gaertn.—Denver; Uinta Mountains.

Antennaria margaritacea, R. Br.—Henry's Fork of Green River.

Senecio lugens, Richards.—Wyoming Territory; August to September.

Senecio cernuus, Gray.—Mountains near Denver.

Senecio longilobus, Benth.—Denver; Wyoming Territory; August to September.

Senecio rapifolius, Nutt.—Wyoming Territory; August to September.

Senecio aureus, L. var.—Mountains near Denver.

Tetradymia inermis, Nutt.—North Park, Colorado Territory.

Tetradymia spinosa, Hook and Arn.—Henry's Fork of Green River.

Arnica mollis, Hook.—Mountains near Denver.

Cirsium undulatum, Spreng.—Near Denver.

Cirsium Drummondii, Torr. and Gray.—Near Denver.

Cirsium edule, Nutt.—Near Denver.

Stephanomeria runcinata, Nutt.—Denver.

Lygodesmia juncea, Don.—Wyoming Territory; August to September.

Troximon glaucum, Nutt.—North Park, Colorado Territory; Uinta Mountains.

Macrorhynchus troximoides, Nutt.—Fall River, Colorado Territory.

Mulgedium pulchellum, Nutt.—Denver; Wyoming Territory; August to September.

CAMPANULACEÆ.

Campanula rotundifolia, L.—Denver; North Park, Colorado Territory.

Campanula Langsdorffiana, Fischer.—North Park, Colorado Territory.

Specularia perfoliata, A. DC.—Near Denver.

ERICACEÆ.

Vaccinium Myrtillus, L.—Wyoming Territory; August to September.

Arctostaphylos Uva-ursi, Spreng.—Denver; Uinta Mountains.

Pterospora Andromedea, Nutt.—North Park, Colorado Territory.

PLANTAGINACEÆ.

Plantago Patagonica, Jacq., var. *gnaphalioides*, Gray.—Near Denver.

Plantago eriopoda, Torr.—Wyoming Territory; August to September.

PRIMULACEÆ.

Dodecatheon Meadia, L.—Uinta Mountains. In fruit.

Androsace filiformis, Retz.—Henry's Fork of Green River.

Androsace septentrionalis, L.—Denver; Uinta Mountains.

Glaux maritima, L.—Wyoming Territory; August to September.

OROBANCHACEÆ.

Aphyllon fasciculatum, Torr. and Gray.—Denver.

SCROPHULARIACEÆ.

Pentstemon glaber, Pursh.—Wyoming Territory; August to September.

Pentstemon cœruleus, Nutt.—Near Denver.

Pentstemon acuminatus, Dougl.—Near Denver.

Pentstemon humilis, Nutt.—Denver; Wyoming Territory; August to September.

Pentstemon confertus, Dougl., var. *cœruleo-purpureus*, Gray.—Mountains near Denver; North Park, Colorado Territory.

Mimulus Jamesii, Torr.—Near Denver.

Mimulus luteus, L., Wyoming Territory; August to September.

Ilysanthes gratioloides, Benth.—North Park, Colorado Territory.

Veronica Americana, Schw.—Henry's Fork of Green River.

Veronica serpyllifolia, L.—Henry's Fork of Green River.

Castilleia integra, Gray.—Near Denver.

Castilleia pallida, Nutt.—Denver; Uinta Mountains.

Orthocarpus luteus, Nutt.—Denver; Uinta Mountains.

Pedicularis bracteosa, Benth.—Mountains near Denver.

Pedicularis Grœnlandica, Retz.—Uinta Mountains.

VERBENACEÆ.

Verbena bracteosa, Michx.—Denver; Wyoming Territory.

Verbena stricta, Vent.—Camp Carlin, Wyoming Territory.

LABIATÆ.

Mentha Canadensis, L.—Henry's Fork of Green River.

Hedeoma Drummondii, Benth.—Wyoming Territory; August to September.

Monarda fistulosa, L.—Near Denver.

Monarda aristata, Nutt.—Near Denver.

Scutellaria resinosa, Torr.—Near Denver.

Scutellaria galericulata, L.—Near Denver.

Stachys palustris, L., var. *aspera*, Gray.—Denver.

Stachys palustris, L., var. *cordata*, Gray.—Wyoming Territory.

BORRAGINACEÆ.

Onosmodium Carolinianum, DC.—Denver.

Mertensia alpina, Don.—Mountains near Denver.

Mertensia paniculata, Don.—Mountains near Denver.

Mertensia Sibirica, Don.—Mountains near Denver, Uinta Mountains.

Lithospermum pilosum, Nutt.—Denver.

Lithospermum hirtum, Lehm.—Denver.

Echinospermum Redowski, Lehm.—Denver, Wyoming Territory.

Echinospermum floribundum, Lehm.—Denver.

Eritrichium crassisepalum, Torr. and Gray.—Denver.

Eritrichium Jamesii, Torr.—Near Denver.

Eritrichium glomeratum, DC., (*Myosotis glomerata*, Hook. Fl. Bor. Am. 2. p. 82. t. 162,) var., *hispidissimum*, Torr. in Emory's Rep. Bound. Surv. 2. p. 140. (fide Gray.)—Camp Carlin, Wyoming Territory, July 30, 1870, F. V. Hayden.—Stem 8 to 10 inches high. Racemes mostly bifid or trifid, 3 to 4 inches long, much surpassing the leaves. Flowers small and somewhat scattered, rather shorter than the acute, lance-ovate bracts. Limb of the corolla 2 lines in diameter, its narrow tube about as long. Nutlets 4, reticulate-rugose on the back.

Eritrichium virgatum, sp. nov. Sesquipedale, hispidissimum; caule simplici tereti erecto; foliis radicalibus oblongo-spathulatis, caulinis linearibus; cymis plurimis in axillis foliorum conglomeratis pedunculatis superne subsessilibus confertisque; calycis 5-partiti segmentis lanceolatis tubum corollæ aequantibus; nuculis 4-ovatis dorso infra partem mediam convexo supra lateribus depresso laevibus nitidis.—Near Denver, Colorado Territory, 1869, B. H. Smith. The stout virgate spike made up of numerous glomerate cymes, crowded in the axils of the linear cauline leaves, which much exceed them in length. Limb of the corolla 4 lines in diameter, its lobes rounded. Nutlets smooth and shining, the lower half of the back convex, the upper depressed on the sides, leaving a central vertical ridge. According to Dr. Gray this plant is the same as Parry's 288, and Hall and Harbour's 438 (in part.) It has passed for a form of *E. glomeratum*, DC., but seems more nearly allied in its fruit and habit of growth to *E. leucophaeum*, A. DC. (*Myosotis leucophæa*, Dougl., in Hook. Fl. Bor. Am. 2. p. 82. t. 163,) and I have ventured to give it a name.

HYDROPHYLLACEÆ.

Hydrophyllum Virginicum, L.—Denver.
Phacelia circinata, Jacq.—Denver.
Phacelia sericea, Gray.—Denver.
Ellisia ambigua, Nutt.—Denver.

POLEMONIACEÆ.

Polemonium confertum, Gray.—Gray's Peak, Colorado Territory.
Collomia linearis, Nutt.—Uinta Mountains.
Gilia congesta, Hook.—Denver; Wyoming Territory.
Gilia pinnatifida, Nutt.—Mountains near Denver.
Gilia aggregata, Spreng.—Denver. With white and red flowers.
Gilia pungens, Benth.—Near Denver.

SOLANACEÆ.

Solanum rostratum, Pursh.—Denver.
Physalis Pennsylvanica, L., var.?—Wyoming Territory; August to September.

GENTIANACEÆ.

Gentiana affinis, Griseb.—Mountains near Denver; North Park, Colorado Territory; Uinta Mountains. Wyoming Territory.
Gentiana Parryi, Engelm.—Mountains near Denver; North Park, Colorado Territory.
Gentiana detonsa, Griseb.—Near Denver.
Gentiana frigida, Haenke, var. *algida*, Griseb.—Gray's Peak, Colorado Territory; Uinta Mountains.
Gentiana acuta, Michx.—Near Denver; Uinta Mountains.
Frasera speciosa, Dougl.—Uinta Mountains.

APOCYNACEÆ.

Apocynum androsæmifolium, L.—Denver.

ASCLEPIADACEÆ.

Asclepias speciosa, Torr.—Near Denver.
Asclepias verticillata, L.—Wyoming Territory. The dwarf variety.

NYCTAGINACEÆ.

Oxybaphus angustifolius, Sweet.—Denver.
Oxybaphus nyctagineus, Sweet.—Denver.
Abronia fragrans, Nutt.—Denver, Wyoming Territory.

CHENOPODIACEÆ.

Cycloloma platyphyllum, Moq.—Denver.
Teloxys cornuta, Torr. in Whipple's, Report, Pacific Railroad Survey, 4. p. 129.—Mountains near Denver.

Blitum capitatum, L.—Denver.

Blitum maritimum, Nutt.—Wyoming Territory; August to September.

Obione argentea, Moq.—Wyoming Territory; August to September.

Salicornia Virginica, L.—Big Sandy, Wyoming Territory; September 8. Whole plant of a bright-red color.

AMARANTACEÆ.

Frœlichia Floridana, Moq.—Denver.

Montelia tamariscina, Gray.—Wyoming Territory; August to September.

POLYGONACEÆ.

Polygonum Bistorta, L.—Near Denver; Uinta Mountains.

Polygonum aviculare, L., var. *erectum*, Roth.—Denver; North Park, Colorado Territory.

Polygonum tenue, Michx., var.—Denver.

Polygonum ramosissimum, Michx.—Wyoming Territory.

Polygonum dumetorum, L.—Wyoming Territory.

Rumex maritimum, L.—Wyoming Territory; August to September.

Oxyria digyna, R. Br.—Uinta Mountains, Wyoming Territory.

Eriogonum umbellatum, Torr.—Denver; Wyoming Territory.

Eriogonum umbellatum, Torr., var. *monocephalum*, Torr and Gray, Rev. Erigon., p. 160.

Eriogonum alatum, Torr., var. *glabriusculum*, Torr., Rev. Erigon, p. 154.—Denver; North Park, Colorado Territory.

Eriogonum microthecum, Nutt., var. *effusum*, Torr. and Gray, l. c., p. 172.—Denver; North Park, Colorado Territory; Wyoming Territory.

Eriogonum brevicaule, Nutt.—Wyoming Territory; August to September; with yellow flowers.

Eriogonum annuum, Nutt.—Denver.

Erigonum cernuum, Nutt.—Wyoming Territory; August to September.

ELÆAGNACEÆ.

Shepherdia Canadensis, Nutt.—Uinta Mountains, Wyoming Territory.

Shepherdia argentea, Nutt.—Henry's Fork of Green River, Wyoming Territory.

EUPHORBIACEÆ.

Euphorbia petaloidea, Engelm.—Denver.

Euphorbia marginata, Pursh.—Denver.

Euphorbia montana, Engelm.—Mountains near Denver.

Croton muricatum, Nutt.—Near Denver.

BETULACEÆ.

Betula papyracea, Ait., var. *pumila*, Regel, in DC. Prod.—Henry's Fork of Green River.

Alnus serrulata, Ait., var. *rugosa*, Regel.—Henry's Fork of Green River.

SALICACEÆ.

Salix cordata, Muhl.—Wyoming Territory; August to September.

Salix longifolia, Muhl.—Denver; Wyoming Territory.

Salix lucida, Muhl, var. *angustifolia*, Anders.—Henry's Fork of Green River.

Populus Canadensis, Desf., var. *angustifolia*, Westmael in DC. Prod. (*P. angustifolia*, Torr.)—Henry's Fork of Green River.

CONIFERÆ.

Ephedra antisyphilitica, Berland.—Wyoming Territory; August to September.

Juniperus communis, L.—Near Denver.

Juniperus occidentalis, Hook.—Wyoming Territory; August to September.

Pinus flexilis, James.—Wyoming Territory.

IRIDACEÆ.

Iris tenax, Dougl.—Denver; Wyoming Territory. In fruit.

LILIACEÆ.

Veratrum viride, Ait.—Uinta Mountains, Wyoming Territory.

Zygadenus glaucus, Nutt.—Uinta Mountains, Wyoming Territory.

Smilacina stellata, Desf.—Denver; Uinta Mountains.

Allium stellatum, Nutt.—Denver.

Allium cernuum, Roth.—Denver.

Allium acuminatum, Hook?—Uinta Mountains, Wyoming Territory. The sepals have a longer acumination than in Hooker's figure (Fl. Bor. Am., t. 196), and the inner ones are not serrulate.

Allium Schœnoprasum, L.—Wyoming Territory; August to September.

Yucca angustifolia, Pursh.—Near Denver.

Calochortus venustus, Benth.—Near Denver.

JUNCACEÆ.

Luzula spicata, Desv.—Uinta Mountains, Wyoming Territory.

Luzula parviflora, Desv., var. *melanocarpa*, Grey.—Uinta Mountains.

Juncus Balticus, Dethard.—Uinta Mountains, Wyoming Territory.

Juncus tenuis, Willd.—Henry's Fork of Green River.

Juncus longistylis, Torr. (*J. Menziesii*, R. Br.)—Denver.

Juncus nodosus, L., var. *megacephalus*, Torr.—Denver.

Juncus Mertensianus, Bong.; Engelm. Rev., p. 479.—Uinta Mountains.

COMMELYNACEÆ.

Tradescantia Virginica, L.—Denver.

CYPERACEÆ.

Eleocharis palustris, R. Br.—Denver.

Scirpus pungens, Vahl.—Denver.

Scirpus maritimus, L.—Wyoming Territory; August to September.

Scirpus atrovirens, Muhl.—Near Denver.

Carex straminea, Schk.—Denver.

Carex festiva, Dew.—Uinta Mountains, Wyoming Territory.

Carex Haydeniana, Olney, sp. nov. Spica ovata vel subrotundata capitata fusco-ferruginea e spiculis sub-6 basi masculis densifloris; bracteis squamaeformis cuspidatis; perigyniis ovatis longe attenuato-rostratis, ore oblique secto, membranaceis compressis alatis; margine duplo-serratis basi leviter nervatis, flavidis superne vel demum omnius fuscis apertis squama ovata acuta margine hyalina longioribus; achenio stramineo lenticulari-elliptico. *Hab.*, California, Bolander, 5074; Uinta Mountains, Wyoming Territory, F. V. Hayden, September, 1870.—The *Carex Haydeni* of Dewey being clearly *C. aperta*, Boott., this is named in honor of the zealous explorer in the realms of natural history whose name it bears. Low, 4 to 6 inches high, caespitose; roots fibrous; leaves flat, narrow, shorter than the culms. Allied to *C. festiva*, Dew.

Carex Bonplandii, Kunth., var. *minor*, Gray, Enum. Pl. Hall and Harbour, p. 77.—Uinta Mountains, Wyoming Territory.

Carex atrata, L.—Uinta Mountains, Wyoming Territory.

Carex rigida, Good.—Uinta Mountains, Wyoming Territory.

Carex utriculata, Boott.—Denver.

GRAMINEÆ.

Alopecurus pratensis, L., var. *alpina*, Wahl.—Near Denver.

Phleum alpinum, L.—Henry's Fork of Green River.

Agrostis perennans, Tuckerm.—Henry's Fork of Green River.

Muhlenbergia glomerata, Trin.—Wyoming Territory, August to September.

Calamagrostis Langsdorffii, Trin.—Wyoming Territory.

Calamagrostis longifolia, Hook.—Wyoming Territory.

Calamagrostis sylvatica, D. C.—Mountains near Denver.

Spartina cynosuroides, Willd.—Wyoming Territory.

Bouteloœa oligostachya, Torr.—Near Denver.

Koeleria cristata, Pers.—Near Denver.

Eatonia obtusata, Gray.—Near Denver.

Brizopyrum spicatum, Hook and Arn., var. *Strictum*, Thurber, Enum., Pl. Hall and Harbour, p. 78.—Wyoming Territory; August to September.

Poa serotina, Ehrh.—Uinta Mountains, Wyoming Territory.

Poa arctica, R. Br.—Uinta Mountains, Wyoming Territory.

Poa Andina, Trin.—Uinta Mountains, Wyoming Territory.

Festuca ovina, L., var.—Near Denver.

Bromus ciliatus, L.—Near Denver.

Bromus kalmii, Gray.—North Park, Colorado Territory.

Triticum repens, L.—Mountains near Denver.

Elymus canadensis, L.—Denver, Wyoming Territory; August to September.

Hordeum jubatum, L.—Denver; Camp Carlin, Wyoming Territory.

Trisetum subspicatum, Beauv., var. *molle*, Gr.—Uinta Mountains.

Aira caespitosa, L.—Uinta Mountains.

Andropogon argenteus, Ell.—Wyoming Territory, August to September.

EQUISETACEÆ.

Equisetum arvense, L.—Denver, Wyoming Territory.

Equisetum hyemale, L.—Wyoming Territory; August to September.

FILICES.

Pellaea atropurpurea, Link.—North Park, Colorado Territory.

Aspidium Filix-mas, Swartz.—Wyoming Territory; August to September.

Woodsia obtusa, Torr.—Wyoming Territory; August to September.

VI.—CATALOGUE OF PLANTS.

A LIST OF PLANTS COLLECTED BY C. THOMAS, IN EASTERN COLORADO AND NORTHEASTERN NEW MEXICO, DURING THE SURVEY OF 1869.

BY DR. C. C. PARRY.

Atragene alpina, L.
Clematis Douglassii, Hook.
ligusticifolia, Nutt.
Pulsatilla Nuttalliana, Gray.
Anemone multifida D. C.
Pennsylvanica, L.
Thalictrum Fendleri, Engelm.
alpinum, L.
Ranunculus cymbalaria, Pursh.
repens, Hook.
affinis, R. B.
Eschscholtzii, Schlecht.
Caltha leptosepala, D. C.
Aquilegia cœrulea, Torr.
Delphinium elatum, L.
Aconitum nasutum, Fisch.
Berberis aquifolium, Pursh.
B. Fendleri, Gray.
Corydalis aurea, Willd.
Argemone Mexicana, L.
Cardamine cordifolia, Gray.
Erysimum asperum, D. C.
Draba aurea, Vahl.
D. streptocarpa, Gray.
Camelina sativa, L.
Smelowskia calycina, C. A. Meyer.
Thlaspi cochleariforme, D. C.
Physaria didymocarpa, Gray.
Vesicaria montana, Gray.
ludoviciana, D. C.
Stanleya integrifolia, James.
Lepidium alyssoides, Gray.
Barbarea vulgaris, L.
Sisymbrium canescens, Nutt.
Cleome integrifolia, Torr and Gray.
Viola canadensis, L.
Nuttalli, Pursh.
Muhlenbergii, Torr.
Ionidum lineare, Torr.
Hypericum Scouleri, Hook.
Silene Menzerii, Hook.
acaulis, L.
Paronychia pulvinata, Gray.
Jamesii, Torr.
Arenaria arctica, Stev.
Fendleri, Gray.
tenella, Gray.
Dryas octopetala, L.
Fragraria Virginiana, L.
vesca, L.
Amelanchier canadensis, Torr. and Gray.
Prunus virginiana, L.
Epilobium alpinum, L.
latifolium, L.
angustifolium, L.
palustre, L.
Gayophytum racemosum, Torr. and Gray.
Œnothera serrulata, Nutt.
pinnatifolia, Nutt.
biennis, L.
marginata, Nutt.
Œnothera coronopifolia, Torr. and Gray.
Gaura coccinea, Nutt.
parviflora, Dougl.
Mentzelia nuda, Torr. and Gray.
multiflora, Nutt.
Opunta arborescens, Engel.
Saxifraga punctata, L.
serpillifolia, Pursh.
bronchialis, L.
flagellaris, Willd.
nivalis, L.
Heuchera hispida, Pursh.
parvifolia, Nutt.
Halli, Gray.
Jamesia americana, Torr. and Gray.
Ribes cereum, Dougl.
aureum, Pursh.
lacustre, Poir.
hirtellum, Michx.
Sedum rhodanthum, Gray.
rhodiola, L.
stenopetalum, Pursh.
Sanicula canadensis, L.
Conioselinum Fischeri, Wimm.
Musenium divaricatum, Nutt.
Thaspium montanum, Gray.
trachypleurium, Gray.
Osmorhiza brevistylis, D. C.
Adoxa Moschatellina, L.
Linnæa borealis, Grouov.

Linnæa Franklinii, Hook.
Cerastium vulgatum, L.
Claytonia megarrhiza, Parry.
Talinum pygmæcum, Gray.
Malvastrum coccineum, Gray.
Sidalea candida, Gray.
    malvæflora, Gray.
Linum perenne, L.
    rigidum, Pursh.
Geranium Richardsonii, F. and M.
    Frémontii, Torr.
Ceanothus ovatus, Desf.
    Fendleri, Gray.
    velutinus, Dougl.
Pachystima Myrsinites, Raf.
Acer glabrun, Torr.
Ptlea trifoliata, L.
Rhus toxicodendron, L.
    aromatica, Ait.
Lathyrus ornatus, Nutt.
Ervum hirsutum, L.
Thermopsis montana, Nutt.
Petalostemon violaceus, Mich'x.
    candidum, Mich'x.
Sophora sericea, Pursh.
Glycyrrhiza Lepidota, Nutt.
Trifolium longipes, Nutt.
    Parryi, Gray.
    dasyphyllum, Torr.
    nanum, Torr.
Lupinus cæspitosus, Nutt.
    pusillus, Pursh.
    ornatus, Dougl.
Dalea laxiflora, Pursh.
    aurea, Nutt.
    formosa, Torr.
Amorpha nana, Nutt.
Astragalus Drummondii, Hook.
    Parryi, Gray.
    cæspitosus, Gray.
    multiflorus, Gray.
    strictus, Nutt.
    bisulcatus, Gray.
    hypoglottis, L.
Oxytropis specosa, Dougl.
    multiceps, Nutt.
    Lamberti, Pursh.
Psoralea floribunda, Nutt.
    lanceolata, Pursh.
    esculenta, Pursh.
Spiræa opulifolia, L.
    dumosa, Nutt.
Sibbaldia procumbens, L.
Chamærhodes erecta, Burr.
Cercocarpus parvifolius, Nutt.
Rubus deliciosus, James.
Symphoricarpus occidentalis, R. Br.
Lonicera involucrata, Banks.
Sambucus pubens, Michx.
Galium boreale, L.
Valeriana dioica, L.
Fedia longiflora, Torr. and Gray.
Liatris punctata, Hook.
Aster salsuginosus, Richards.
Erigeron philadelphicum, L.
    grandiflorum, Hook.
    macanthrum, Nutt.
    compositum, Pursh.
Solidago virga aurea, L.
Diplopappus ericoides.
Aplopappus armerioides, Torr. and Gray.
Aplopappus Frémonti, Torr. and Gray.
Aplopappus Parryi, Gray.
    Nuttalliana, Gray.
Chrysopsis villosa, Nutt.
Lepachis columnaris, Torr. and Gray.
Gaillardia aristata, Pursh.
Helianthella uniflora, Torr. and Gray.
Helianthus pumilus, Nutt.
    petiolaris, Nutt.
Actinella grandiflora, Torr. and Gray.
Actinella scaposa, Nutt.
    acaulis, Nutt.
Hymenopappus tenuifolius, Pursh.
Macheranthera canescens, Gray.
Grindelia squarosa, Duval.
Townsendia grandiflora, Nutt.
    serricea, Hook.
    Fendleri, Gray.
Linosyris graveoleus, Torr. and Gray.
Linosyris viscidiflora, Torr. and Gray.
Pectis angustifolia, Torr.
Artemesia scopulorum, Gray.
    tridentata, Nutt.
    borealis, Pall.
    frigida, Willd.
    filifolia, Torr.
Antennaria dioica, R. Br.
    Carpathica, D. C.
Rudbeckia laciniata, L.
Zinnia grandiflora, L.
Ximenesia encelioides, Cav.
Melampodium cinereum, D. C.
Achillea millelifolium, L.
Bahia absinthifolia, Benth.

Rubus strigosus, L.
Nutkanus, Mocino.
Rosa blanda, Ait.
Geum rivale, L.
triflorum, Pursh.
Rossii, Seringe.
Crategus rivularis, Hook.
Potentilla diversifolia, Lehm.
Norvegica, L.
fissa, Nutt.
fruticosa, L.

Vaccinium myrtillus, L.
Arctostaphylos uva-ursi, Spreng.
Kalmia glauca, L.
Pyrola minor, L.
secunda, L.
chlorantha, Swartz.
uniflora, L.
Plantago Patagonica, Lam.
Primula angustifolia, Torr.
Parryi, Gray.
Androsace filiformis, Retz.
septentrionalis, L.
chamæjasme, L.
Dodecatheon meadia, L.
Lysmachia ciliata, L.
Aphyllon fasciculatum, Torr. and Gray.
Pentstemon glaber, Pursh.
acuminatus, Dougl.
glaucus, Graham.
pubescens, Soland.
humilis, Nutt.
Scrophularia nodosa, L.
Mimulus Jamesii, Torr.
Synthris plantaginea, Benth.
Veronica alpina, L.
Castilleja pallida, Kunth.
sessiliflora, Pursh.
integra, Gray.
Orthocarpus luteus, Nutt.
Pedicularis racemosa, Benth.
Groenlandica, Retz.
Parryi, Gray.
Scutellaria resinosa, Torr.
galericulata, L.
Monarda aristata, Nutt.
Dracocephalum parviflorum, Nutt.
Teucrium cubense, L.
Verbena anbletia, L.
Echinospermum floribundum, Lehm.
Eritrichium glomeratum, D. C.
crassisepalum, Torr.
arctioides, D. C.
Lithospermum pilosum, Nutt.
Arnica angustifolia, Vahl.
Senecio integerrimus, Nutt.
aureus, L., (variety.)
triangularis, Hook.
eremophyllus, Richard.
Cirsium acaule, All.
Mulgedium pulchrum, Nutt.
Troximon glaucum, Nutt.
Lygodesmia juncea, Don.
Campanula Langsdorfiana, Fischer.
C. uniflora, L.
Campylocera leptocarpa, Nutt.
Eriogonum alatum, Torr.
umbellatum, Torr.
flavum, Nutt.
brevicaule, Nutt.
Comandra pallida, D. C.
Arcenthobium campylopodum, Engel.
Euphgrbia maroinata, Pursh.
montana, Engel.
Croton muricatum, Nutt.
Tragia ramosa, Torr.
Quercus Douglasii. D. C.
Corylus rostrata, Ait.
Betula glandulosa, Michx.
Salix glauca, L.
Populus angustifolia.
Pinus ponderosa, Dougl.
contorta, Dougl.
flexilis, James.
aristata, Engel.
edulis, Engel.
Abies Menziesii, Lindl.
Engelmanii, Parry.
grandis, Lindl.
Platanthera hyperborea, Lindl.
Calypso borealis, Salisb.
Spiranthus cornua, Richard.
Goodyera Menziesii, Lindl.
Iris tenax, Dougl.
Sisyrinchium Bermudiana.
Streptopus amplexifolius, D. C.
Smilacina stellata, Desf.
racemosa, Desf.
Lilium Philadelphicum, L.
Erythronium grandiflorum, Pursh.
Allium cernuum, Roth.
Leucocrinium montanum, Nutt.
Calochortus venustus, Benth.
Lloydia serotina, Reich.
Yucca baccata, Torr.
angustifolia, Pursh.
Zygadenus glaucus, Nutt.
Juncus tenuis, L.

Lithospermum longiflorum, Sprang.
Mertensia alpina, Don.
Sibirica, Don.
Polemonium cæruleum, L.
pulchellum, Bunge.
confertum, Gray.
Phlox Douglassii, Hook.
Hoodii, Richardson.
Colomia linearis, Nutt.
Gilia pinnatifolia, Nutt,
aggregata, Sprang.
spicata, Nutt.
congesta, Hook.
longiflora, Benth.
Evolvulus argenteus, Pursh.
Ipomea leptophylla, Torr.
Solanum triflorum, Nutt.
rostratum, Don.
Physalis lobata, Torr.
Phacelia Popei, Torr and Gray.
circinata, Jacq.
sericea, Gray.
Hydrophyllum virginicum, L.
Nama dichotoma, Chois.
Ellisia nyctelea, L.
Gentiana acuta, Michx.
Parryi, Gray.
affinis, Griesb.
Frasera speciosa, Dougl.
Asclepias tuberosa, L.
verticillata, L.
speciosa, Torr.
Apocynum canabinum, L.
Abronia fragrans, Nutt.
Oxybaphus nyctagineus, Sweet.
Allionia incarnata, L.
Polygonum bistorta, L.
viviparum, L.
tenue, Michx.
Oxyria digyna, R. Br.
Rumex venosus, Pursh.
Juncus Mertensianus, C.A.Meyer.
Parryi, Engel.
Luzula spicata, D. C.
parviflora, D. C.
Cyperus Schweintzii, Torr.
Scivpus pungens, Vahl.
Carex scoparia, Selk.
atrata, L.
Muhlenbergia gracilis, H. B. K.
graciliura, Torr.
aspericaulis, Nees.
Sporobolus ramuloides, H. B. K.
Sporobolus asperifolius, Nees and Meyer.
Panicum capillare, L.
Spartina cynosuroides, Willd.
Phleum alpinum, L.
Aristida purpurea, Nutt.
Kœleria aristata, Pers.
Trisetum subspicatum, Beauv.
Brizopyrum spicatum, Hook.
Vilfa tricholepis, Torr.
Munroa squarrosa, Torr.
Buchloe dactyloides, Engel.
Bouteloua oligastachya, Nutt.
B. curtipendula, Gray.
Festuca tenella, Willd.
F. ovina, L.
Poa alpina, L.
Sitanion elymoides, Ref.
Hordeum jubatum, L.
Triticum caninum, L.
T. Phleoides, H. B. K.
Sclerochloa Californica, Munro.
Setaria, caudata.
Eragrostis poæoides, Beaur.
Chelanthes Fendleri, Hook.
Nothochlæna Fendleri, Kunze.
Woodsia obtusa, Torr.
Asplenium septentionale, L.
Cystopteris fragilis, Bernh.

NOTE.—The foregoing list of plants is inserted for the purpose of furnishing some data to botanists in ascertaining the general distribution of the species therein named. My duties in other departments did not allow me time to make notes in regard to special localities, elevations, &c.

C. THOMAS.

APPENDIX.

METEOROLOGY, &c.

BY MR. J. W. BEAMAN.

QUARTERMASTER'S DEPOT, FORT D. A. RUSSELL,
November 1, 1870.

SIR: I have the honor herewith to present the meteorological notes taken during the month of July, August, September, and October, while connected with the geological survey of Wyoming Territory under your charge. These notes have been taken in connection with other duties, not in a professional, but rather in an amateur way. This will, I trust, account for many apparent imperfections and omissions. The instruments placed at my disposal were an aneroid barometer with accompanying Fahrenheit thermometer; a Fahrenheit thermometer manufactured by C. A. Siefert, Boston, Massachusetts; two Fahrenheit thermometers manufactured by J. Kendall & Co., New Lebanon, New York; also, one odometer for the measurement of the road. There has been a barometric observation taken at every camp and many points of importance on the survey. As will be seen by an inspection of the tables, the observed readings at the same place often vary several tenths of an inch. This is owing to a change in density of the atmosphere each hour, and with every wind and rain; hence the heights are but approximately indicated. There has been no allowance made for a change in temperature, as it is but slight. There has been no allowance made for the wind, as I have had no means of determining its force. I have made no allowance for moisture, as I have had no hygrometer. The rule which has been followed in making the estimates of elevation is one given by J. H. Bellville, of the Royal Observatory, Greenwich. *Rule.*—"As the sum of the readings of the barometer is to their difference, so is 55,000 (or twice the assumed height of the atmosphere in feet) to the elevation required."

This rule is founded on the supposition that the height of the atmosphere is 27,500 feet, with the barometer at 30 inches and the thermometer at 55° Fahrenheit. The temperature has been noted at the time of taking each reading; so that if there could be a more accurate estimate made by allowing for a change, it might be made. The aneroid is one purchased in Philadelphia of McAllister & Bro., 728 Chestnut street. The divided circle is only two inches in diameter. Its small size recommends it to those desiring a very convenient portable instrument; but on the other hand it is too small for the most accurate work. The temperature during the time occupied in the field has ranged from 103°, Quartermaster's Department, Fort D. A. Russell, July 28, 2.30 o'clock p. m., down to 8°, Big Pond Stage Station, Bitter Creek, 3.30 o'clock a. m., October 17. We have experienced few storms of rain or snow. The general direction of the wind has been from northwest or southwest. On the evening of September 24, at Camp Elliott, there was a most gorgeous display of the aurora borealis. It was first noticed about half past eight o'clock in the evening, when the northeast quarter of the heavens was one glow of deep crimson flame. There was very little shooting upward of narrow bands of light, but rather a gradual change of color. Later in the night the northwest quarter became suffused in the same manner.

The odometer has worked admirably, showing as the distance traveled by the train 888.196 miles. This does not include the trips made by yourself to the head-waters of the Chugwater Creek, Laramie Peak, Box Elder Cañon, Uinta Mountains, the sources of Bear River, the source of Henry's Fork of Green River, and Brown's Hole, which brings up the estimate to 1,400 miles, making a daily average of about 18 miles.

In conclusion, let me here add that my work in this department has been attended with an increasing interest as the months have gone by, and my only regret is that it is not more thoroughly done.

I have the honor to be your very obedient servant,

J. W. BEAMAN.

Dr. F. V. HAYDEN.

Meteorological notes taken during the months of July, August, September, and October.

Howard's nomenclature of the clouds has been followed in these tables.
ABBREVIATIONS.—Cir., cirrus; cu., cumulus; str., stratus; cir.-cu., cirro-cumulus; cu.-str., cumulo-stratus; cir.-str., cirro-stratus.

Point of observation.	Date.	Hour of day.	Barometric reading.	Fahrenheit. Ther. No. 1.	Ther. No. 2.	Ther. No. 4.		Approximate elevation.	Intermediate distance traveled.	Total distance traveled.	Direction of wind.	Clouds and general remarks.
Q. M. Depot, Fort D. A. Russell, on the flat, southeast of the sutler's store. (Camp.)	July 27	3. 00 p. m.	23. 85	89	89	86	86	6, 455			Prevailing winds from N. W. quarter.	
	July 28	9. 00 a. m.	24.	83	83	81	83					
	July 28	2. 30 p. m.	23. 9	103	103	100	101					
	July 28	5. 00 p. m.	23. 8	91	91	88	87					
	July 28	8. 00 p. m.	23. 825	75	75	74	74					
	July 28	9. 30 p. m.	23. 825	66	66	68	67					
	July 29	7. 30 a. m.	23. 825	80	80	79	80					
	July 29	12. 00 m.	23. 7	93	93	91	93					
	July 29	3. 00 p. m.	23. 6	90	90	88	88					
	July 29	9. 00 p. m.	23. 675	68	69	72	75					
	July 30	7. 00 a. m.	23. 7	80	79	80	78					
	July 30	9. 00 a. m.	23. 6	98	98	96	99					
	July 30	11. 00 a. m.	23. 475	105	104	100	105					
	July 30	12. 00 m.	23. 6	90	89	90	90					
	July 30	6. 00 p. m.	23. 65	76	75	74	74					
	July 31	9. 00 a. m.	23. 6	92	92	89	90					
	July 31	7. 00 p. m.	23. 55	78	78	76	78				N. W.	Heavy wind with rain during P. M.
	Aug. 2	2. 00 p. m.	23. 6	98	97	96	95					
	Aug. 6	8. 00 a. m.	23. 575	60	60	57	59					Rain during the day.
	Aug. 7	8. 00 a. m.	23. 575	57	57	56	56				N. E.	Rain during the day.
Lodge Pole Creek on the bottom near the bridge. (Camp.)	Aug. 8	6. 00 a. m.	23. 575	33	34	34	32	6, 449	16.			Clear. Ice formed during the night.
												Clear.
Chugwater Creek on the bottom. (Camp)	Aug. 9	7. 00 a. m.	24. 58	64	64	63	63	5, 285	31. 902	47. 902		Clear.
Chugwater Creek on the bottom. (2d Camp)	Aug. 9	8. 00 p. m.	24. 9	58	59	56	58	5, 150	11. 58	59. 482		Clear.
	Aug. 9	10. 00 a. m.	24. 825	51	51	52	52					Cu. in W.
Big Laramie River on the bottom. (Camp)	Aug. 9	5. 30 p. m.	24. 45	66	65	62	65	4, 513	18. 302	77. 784		Cu. in W.
On the bluff east Big Laramie River. (Camp)	Aug. 9	6. 00 p. m.	25. 25	62				4, 728				NOTE.—The original record, as furnished by Mr. Beaman from August 11 to August 29, was accidentally lost. The following notes are furnished from the memorandum taken by Mr. Thomas.
Big Laramie. (Camp)	Aug. 11	6. 00 a. m.	25. 45	54	53							
Bitter Cottonwood. (Camp)	Aug. 11	8. 00 p. m.	25. 375	53	50			4, 593				
Another point	Aug. 13	1. 00 p. m.	24. 8	83	81			5, 218				
Another point	Aug. 14	5. 00 a. m.	24. 99	58	55			5, 011				
La Bonte Creek. (Camp)	Aug. 14	6. 00 p. m.	25. 025	65	64			4, 986				
	Aug. 15	6. 00 a. m.	25. 025	56	55							
	Aug. 15	12. 00 m.	24. 975	91	91							
	Aug. 15	7. 00 p. m.	25.	76	72							

	Aug. 16	5.00 a. m.	25.025	50	49							
	Aug. 16	6.00 a. m.	25.025	52	50							
La Prele, near Fort Fetterman, two miles west of the Platte.	Aug. 16	1.00 p. m.	24.925	80	79			5,012				
	Aug. 17	11.00 a. m.	24.825	88	87							
	Aug. 17	6.00 p. m.	24.625	79	79							This reading rejected.
	Aug. 18	7.00 a. m.	24.925	44	44							
	Aug. 18	11.00 a. m.	24.925	45	45							
	Aug. 18	8.00 p. m.	24.975	40	40							
	Aug. 19	6.00 a. m.	25.08	56	56							
	Aug. 19	6.00 p. m.	25.08	44	44							
	Aug. 20	5.00 a. m.	25.1	47	46							
	Aug. 20	9.00 a. m.	25.1	51	51							
Box Elder Creek. (Camp)	Aug. 20	3.00 p. m.	25.5	75	75							This reading rejected.
	Aug. 20	6.00 p. m.	25.1	69	69			4,973				
	Aug. 21	6.00 a. m.	24.95	48	50							
Camp on North Platte, near Big Muddy Creek. (Camp.)	Aug. 21	6.00 p. m.	24.8	67	66			5,265				
	Aug. 22	6.00 a. m.	24.725	67	65							
	Aug. 22	11.00 a. m.	24.75	83	83							
Camp on North Platte, 5 miles below the Old Bridge. (Camp.)	Aug. 22	1.00 p. m.	24.77	75	74			5,252				
	Aug. 23	5.00 a. m.	24.77	64	64							
	Aug. 23	7.00 a. m.	24.77	76	74							
Red Buttes. (Camp)	Aug. 23	7.00 p. m.	24.35	70	70			5,528				
	Aug. 24	12.00 m.	24.56	73	72							
	Aug. 24	6.00 a. m.	24.525	55	54							
Foot of Great Cañon	Aug. 24		24.325	72				5,745				
Top of Great Cañon	Aug. 24		23.775	72				6,367				
(Camp)	Aug. 24	9.00 p. m.	24.665	51	52							
	Aug. 25	6.00 a. m.	24.76	34	34							Rejected.
Willow Creek. (Camp)	Aug. 25	4.00 p. m.	23.975	78	78			6,139				
	Aug. 26	7.00 a. m.	23.975	42	42							
Independence Rock, on Sweetwater River. (Camp.)	Aug. 26	7.00 p. m.	24.025	75	75							Rejected.
	Aug. 27	7.00 a. m.	24.1	62	62			5,998				
Top of the rock	Aug. 27		23.96					6,167				
	Aug. 27		23.94									
Camp Gifford. (Camp)	Aug. 28	6.00 p. m.	24.08	64	64			6,021				
	Aug. 29	6.00 a. m.	24.08	44	44							
Mountain north and opposite Camp Gifford	Aug. 29	3.45 p. m.	23.28	58				6,937				Cir.-cu.
Sweetwater River, Three Crossings. (Camp Gifford.)	Aug. 29	6.00 p. m.	23.98	45	43	45	43	6,134	14.46	266.863		Cir.-cu. upon the horizon.
Sweetwater River, near St. Mary's telegraph station. (Camp.)	Aug. 30	5.00 p. m.	23.58	72	72	70	72	6,720	25.7	292.563	W.	Clear.
	Aug. 31	9.00 a. m.	23.52	53	53	52	54					Clear.
Ridge of the foot-hills Wind River Mountains.	Aug. 31	11.00 a. m.	23.32	72				6,894				Cu.-str.
	Aug. 31	12.00 m.	23.1	77				7,147				Cir.-cu. on the horizon.
	Aug. 31	1.00 p. m.	22.92	77				7,356				Cir.-cu. on the horizon.
	Aug. 31	2.30 p. m.	22.88	79				7,405				Cir.-cu.
	Aug. 31	3.00 p. m.	22.78	82				7,524				Cir.-cu.
Strawberry Creek Springs. (Camp)	Aug. 31	4.30 p. m.	23.17	77	77	78	75		22.59	315.153		Cir.-cu.
	Aug. 31	9.00 p. m.	23.05	55	55	54	54	7,201				Cir.-str.
	Sept. 1	6.00 a. m.	23.06	45	45	45	44					Nimbus.
On the plateau of vertical slate ridges	Sept. 1	11.00 a. m.	22.62	67	67	67	66	7,808				Cu.-str.
Fort Stambaugh. (Camp)	Sept. 1	3.00 p. m.	22.62	67	67	67	66	7,732	12.6	327.753		Cu.-str.
	Sept. 2	9.00 a. m.	22.67	59	59	55	57					Cir.

Meteorological notes taken during the months of July, August, September, and October—Continued.

Point of observation.	Date.	Hour of day.	Barometric reading.	Fahrenheit. Ther. No. 1.	Ther. No. 2.	Ther. No. 4.		Approximate elevation.	Intermediate distance traveled.	Total distance traveled.	Direction of wind.	Clouds and general remarks.
Snake Indians' camp, southwest Atlantic City	Sept. 2	2.00 p. m.	22.25	70				8,158				Cir.
South Pass Hotel, South Pass City	Sept. 2	4.00 p. m.	22.5	82				7,857			W.	Cir.
Quartermaster's office Atlantic City	Sept. 2	7.00 p. m.	22.66	73				7,666				Cir.
Fort Stambaugh. (Camp)	Sept. 2	8.30 p. m.	22.62	51	51	49	50	7,684				Cir.
	Sept. 3	6.30 a. m.	22.67	36	36	34	38				W.	Clear.
Steam saw-mill Wind River Mountains	Sept. 3	11.00 a. m.	21.75	74				8,768			W.	Clear.
On the Indian trail near the top of mountains	Sept. 3	12.30 p. m.	21.7	74				8,829				Clear.
Photograph Station, Wind River Mountains	Sept. 3	1.30 p. m.	20.88	74				9,858			W.	Cir.-cu.
Camp west of the Atlantic and Pacific divide	Sept. 3	7.00 p. m.	20.9	50				9,846			W.	Nimbus. Rain.
	Sept. 4	6.30 a. m.	20.88	54							W.	Nimbus and cu.-str. Strong wind.
Point of general view west side of mountains	Sept. 4	10.00 a. m.	20.7	50				10,089			W.	Cir.-str.
Highest reading taken on point of rocks north of trail.	Sept. 4	12.00 m.	20.6	76				10,215			W.	Cir.-cu.
Steam saw-mill	Sept. 4	2.00 p. m.	21.42	76				9,177				Cir.-cu.
Camp Fort Stambaugh	Sept. 4	11.00 p. m.	22.5	36	36	34	36	7,875				Clear.
	Sept. 5	6.00 a. m.	22.47	26	26	25	26					Clear.
On the plateau between Atlantic City and Sweetwater River. 1st point	Sept. 5	12.00 m.	22.42	68				7,953			W.	Cir.-cu.
2d point.	Sept. 5	12.45 p. m.	22.7	72				7,619			W.	Cir.-cu.
On the Atlantic and Pacific divide	Sept. 5	2.00 p. m.	22.23	72				8,182			W.	Cir.-cu.
Pacific Springs, one mile east of Stage Station. (Camp.)	Sept. 5	3.00 p. m.	22.75	68	68	68	68	7,144	18	345.753	W.	Cir.-cu.
	Sept. 5	4.30 p. m.	23.28	68	67	66	68					Cir.-cu.
Mountain south of Pacific Springs. (Camp)	Sept. 5	5.30 p. m.	22.68	68				7,642				Cir.-str.
Pacific Springs. (Camp)	Sept. 5	10.00 p. m.	23.28	50	50	48	50					Clear.
On the Atlantic and Pacific divide, 2d reading	Sept. 6	6.30 a. m.	22.98	46				7,391				Cir.
Pacific Springs. (Camp)	Sept. 6	7.00 a. m.	23.28	46	46	45	46					Cir.
Dry Sandy Creek Ford at Stage Station	Sept. 6	9.30 a. m.	23.52	70				6,641				Cir.
On the plateau west Dry Sandy Creek	Sept. 6	12.00 m.	23.75	65				6,395				Cir.
Little Sandy Creek at Stage Station. (Camp)	Sept. 6	3.00 p. m.	23.7	62	62	63	61	6,354	23.34	369.093		Cir.-cu.
	Sept. 6	9.00 p. m.	23.7	50	49	50	50					Cir.
	Sept. 7	7.00 a. m.	23.96	52	52	51	52					Clear.
Big Sandy Creek Ford at Stage Station	Sept. 7	9.30 a. m.	24.12	70				5,976				Cir. very little.
Bridge west of Big Sandy Ford	Sept. 7	10.45 a. m.	24	72				6,111				Clear.
Big Sandy Creek on the bottom. (Camp)	Sept. 7	3.00 p. m.	24.14	80	79	79	80	5,818	24.84	393.933	W.	Clear.
	Sept. 7	9.00 p. m.	24.28	48	48	48	50					Clear.
	Sept. 8	6.15 a. m.	24.36	34	34	32	34					Clear.
Green River on the bottom, half a mile below the ford. (Camp.)	Sept. 8	1.45 p. m.	24.54	90	89	87	88	5,507	977	403.703		Cir. very little on the horizon.
	Sept. 8	4.00 p. m.	24.54	80	78	76	78					Cir. very little on the horizon.
	Sept. 8	7.00 p. m.	24.55	64	62	62	63					Cir.-str.

Green River Camp	Sept.	8	9.00 p.m.	24.56	54	56	52	53					Cir.
	Sept.	9	6.00 p.m.	24.5	34	34	34	34					Cir.-str.
Black's Fork of Green River on the bottom, at	Sept.	9	3.30 p.m.	24.32	77	78	76	75	5,815	19.997	423.70		Nimbus.
Granger Station. (Camp.)	Sept.	9	9.00 p.m.	24.25	64	64	63	64					Nimbus.
	Sept.	10	6.00 a.m.	24.24	36	36	33	35					Cir. around the horizon.
	Sept.	10	6.45 a.m.	24.24	44	44	44	46					Cir. around the horizon.
Church Buttes, base	Sept.	10	12.00 m.	24.18	72				5,908				Cu.-str. around the horizon.
Church Buttes, top	Sept.	10	12.30 p.m.	24.08	72				6,021			W.	Cu.-str. around the horizon.
Black's Fork, on the bottom, two miles north-	Sept.	10	3.45 p.m.	24.18	85	85	85	86		125.57	436.257	N. W.	Cu.-str.
west Church Buttes. (Camp.)	Sept.	10	6.45 p.m.	24.25	71	71	69	70	5,863			N. W.	Cu.-str.
	Sept.	10	9.00 p.m.	24.24	54	54	54	54				N. W.	Cu.-str. a very little.
	Sept.	11	6.00 a.m.	24.25	37	37	34	35					Clear.
	Sept.	11	8.00 a.m.	24.25	51	51	49	50					Hazy.
Buttes, southwest Church Buttes, base	Sept.	11	8.45 a.m.	24.22	68				5,863				Hazy.
Buttes, southwest Church Buttes, top	Sept.	11	9.00 a.m.	24.1	70				5,998				Hazy.
High Plateau Butte, top	Sept.	11	10.15 a.m.	23.98	74				6,134				Hazy.
Black's Fork. (Camp)	Sept.	11	1.00 p.m.	24.25	74	74	73	74					Cu.-str. hazy.
	Sept.	11	6.45 p.m.	24.14	66	66	65	66					Cu.-str.
	Sept.	12	6.00 a.m.	24.2	36	36	36	36					Cir.-str.
Miller's Stage Station	Sept.	12	9.00 a.m.	24.18	55				5,908				Smoky to northwest.
Black's Fork, Fort Bridger. (Camp)	Sept.	12	3.00 p.m.	23.88	85	85	83	84	6,215	18	454.257	N. W.	Cu.-str.
	Sept.	12	6.00 p.m.	23.88	75	75	72	73				N. W.	Cir.-str. on the horizon.
	Sept.	13	6.00 a.m.	23.85	44	44	43	44					Cir.-str.
	Sept.	13	9.00 a.m.	23.84	62	62	60	64					Clear.
	Sept.	13	7.00 p.m.	23.88	53	53	52	53				W.	Cir. strong wind.
	Sept.	14	7.00 a.m.	23.88	40	40	39	40				W.	Cu.-str.
	Sept.	14	10.00 a.m.	23.91	45	45	45	46				W.	Cir.-cu. Snowing on the Uinta Mts.
	Sept.	14	3.00 p.m.	23.91	53	53	53	49				W.	Cir.-cu.
	Sept.	14	9.00 p.m.	23.94	44	44	43	44					Clear.
	Sept.	15	6.00 a.m.	23.91	33	33	33	33					Cu.-str. and nimbus.
	Sept.	15	9.00 a.m.	23.94	49	49	47	49					Cu.-str. and nimbus.
	Sept.	15	3.00 p.m.	23.94	57	57	54	56					Cu.-str. and nimbus.
	Sept.	15	6.00 p.m.	23.98	55	55	53	54					Cu.-str. and nimbus.
	Sept.	15	9.00 p.m.	23.98	44	44	47	44					Cu.-str. and nimbus.
	Sept.	16	6.00 a.m.	23.9	29	29	26	29				E.	Cir. around the horizon.
	Sept.	16	9.00 a.m.	23.98	49	49	47	48					Cu.-str. and nimbus.
Judge Carter's steam saw-mill	Sept.	16	5.00 p.m.	22.36	42				8,079				Cu.-str. and nimbus. Clearing up.
	Sept.	16	9.00 p.m.	22.26	52								Nimbus.
	Sept.	17	6.00 a.m.	22.32	32								Cu.-str. and str.
	Sept.	17	9.00 a.m.	22.32	41								Nimbus.
Pleasant Point	Sept.	17	10.15 a.m.	22.08	48				8,364				Nimbus.
South end Sage Bush Flat	Sept.	17	10.30 a.m.	21.88	46				8,608				Nimbus.
Porcupine Point	Sept.	17	11.00 a.m.	21.78	44				8,731				Nimbus.
Charlie's Fork, ford	Sept.	17	11.45 a.m.	21.62	44				8,929				Nimbus. Hail and rain.
Camp Jackson	Sept.	17	1.15 p.m.	21.42	48				9,099				Nimbus.
	Sept.	17	6.00 p.m.	21.48	38								Cir.-cu. Nimbus clearing away.
	Sept.	18	6.00 a.m.	21.55	33							S. W.	
Ridge running parallel to east fork Black's Fork.	Sept.	18	10.00 a.m.	20.98	32				9,605			S. W.	Nimbus. Slight snow-storm.
Limestone Ridge, Photograph Ridge	Sept.	18	12.00 m.	20.85	44				9,869			S. W.	Nimbus.
Camp Jackson	Sept.	18	9.00 p.m.	21.48	34							S. W.	Clear.
	Sept.	19	6.00 a.m.	21.56	34							S. W.	Cir.-str.

Meteorological notes taken during the months of July, August, September, and October—Continued.

Point of observation.	Date.	Hour of day.	Barometric reading.	Fahrenheit. Ther. No. 1.	Ther. No. 2.	Ther. No. 4.		Approximate elevation.	Intermediate distance traveled.	Total distance traveled.	Direction of wind.	Clouds and general remarks.
Carter's Lake	Sept. 19	10.00 a. m.	20.52	44				10,321			S. W.	Cir.
Limit of arborescent vegetation	Sept. 19	10.15 a. m.	20.4	44				10,476			S. W.	Cir.-cu.
First peak west of Cathedral Rock	Sept. 19	12.00 m.	19.35	38				11,869			S. W.	Cir. and cir.-cu. in S. W.
Photograph Station, east fork of east fork of Black's Fork.	Sept. 19	1.00 p. m.	20.13	65				10,829			S. W.	Cir.-cu. and cu.-str.
Northwest corner of basin north of Cathedral Rock.	Sept. 19	1.30 p. m.	20.48	64				10,370			S. W.	Cir.-cu. and cu.-str.
Extreme limit arborescent vegetation	Sept. 19	2.30 p. m.	20.16	68				10,769			S. W.	Cir.-cu. and cu.-str.
Photograph Station, east fork Black's Fork	Sept. 19	4.15 p. m.	20.2	60				10,737			S. W.	Cir.-cu. and cu.-str.
Rock Spring	Sept. 19	4.30 p. m.	20.3	59				10,606			S. W.	Cu.-str.
Camp Jackson	Sept. 19	9.00 p. m.	21.42	34							S. W.	Nimbus.
	Sept. 20	6.00 a. m.	21.42	38							S. W.	Nimbus.
Pleasant Point	Sept. 20	9.00 a. m.	22.05	56							S. W.	Nimbus.
Archie's Fork, ford	Sept. 20	9.15 a. m.	22.1	56				8,340			S. W.	Nimbus.
Photograph Station, Quaking Asp Grove	Sept. 20	10.00 a. m.	21.95	64				8,503			S. W.	Nimbus clearing away.
Willow Creek Crossing	Sept. 20	11.00 a. m.	22.55	64				7,795			S. W.	Nimbus clearing away.
Smith's Fork, south ford	Sept. 20	1.00 p. m.	23.32	68				6,890			S. W.	Nimbus clearing away.
Black's Fork, Fort Bridger. (Camp)	Sept. 20	3.00 p. m.	23.72	64				6,411			N. W.	Cir.-cu.
	Sept. 20	9.00 p. m.	23.88	40	40	40	40					Cir.
	Sept. 21	6.00 a. m.	23.76	32	32	32	31					Cir.
	Sept. 21	9.00 a. m.	23.88	56	56	54	56				N. E.	Cir. in E. horizon.
	Sept. 21	3.00 p. m.	23.88	62	62	60	63				N. E.	Cu. and cu.-str.
	Sept. 21	6.00 p. m.	23.88	49	48	47	48				N. E.	Nimbus in S. W. over the Uinta Mts.
	Sept. 22	6.00 a. m.	24	39	39	38	37				N. E.	Nimbus. Hail.
	Sept. 22	3.00 p. m.	23.88	46	46	45	46				N. E.	Nimbus.
	Sept. 23	6.00 a. m.	23.88	27	27	26	31					Cir. and Cu.-str.
	Sept. 24	6.00 a. m.	23.88	34	34	32	34					Cir.-str. in the N.
Ranch on east of swamp, northw't Black's Fork	Sept. 24	1.00 p. m.	23.023	57				7,239			W.	Cir.-cu.
Swamp Valley	Sept. 24	2.00 p. m.	23	57				7,576			W.	Cir.-cu.
Quaking Asp Hill divide	Sept. 24	2.30 p. m.	22.5	57				7,857			W.	Cu-str..
Table Butte	Sept. 24	2.45 p. m.	22.4	57				7,977			W.	Cu.-str.
Branch of Muddy Creek, ford	Sept. 24	3.00 p. m.	22.82	62				7,476			W.	Cu.-str.
Second Branch of Muddy Creek, ford	Sept. 24	3.15 p. m.	22.92	60				7,356			W.	Cu.-str.
Divide east Dry Muddy Creek	Sept. 24	4.00 p. m.	22.78	59				7,336			W.	Cu.-str.
Head-waters Muddy Creek, Camp Elliott	Sept. 24	4.15 p. m.	22.88	58				7,443			W.	Cu.-str.
	Sept. 24	5.30 p. m.	22.18	52					Rejected		W.	Cu.-str.
	Sept. 25	6.00 a. m.	22.22	26					Rejected		W.	Cu.-str. Magnificent display of Aurora Borealis night of 24th.

Divide between Sulphur and Muddy Creeks	Sept. 25	9.00 a. m.	22.22	52				8,194			W.	Cu.-str.
Reading, at a second point on divide between Sulphur and Muddy Creeks.	Sept. 25	9.15 a. m.	22.3	52				8,096			W.	Clear.
Sulphur Creek at foot of ridge, divide	Sept. 25	10.00 a. m.	22.52	52				7,833			W.	Clear.
Steam saw-mill	Sept. 25	11.00 a. m.	21.88	52				8,608			W.	Clear.
Limit of quaking asps	Sept. 25	11.30 a. m.	21.32	52				9,302			W.	Clear.
Limit of quaking asps, second point	Sept. 25	12.00 m.	21.22	55				9,428			W.	Cu.-str. a very little.
Highest point Spence Ridge	Sept. 25	12.15 p. m.	20.88	55				9,857			W.	Cu.-str. a very little.
Dinner camp at spring east Spence Ridge	Sept. 25	2.30 p. m.	21.55	50				9,016			W.	Cu.-str. a very little.
Divide between west fork Black's Fork and east fork Bean River.	Sept. 25	3.00 p. m.	21.15	58				9,516			W.	Cu.-str. a very little.
Center of prairie, divide	Sept. 25	6.15 p. m.	20.56	44				10,269			W.	Cu.-str. a very little.
Center of second prairie, near springs	Sept. 25	6.45 p. m.	20.53	40				10,231			W.	Cu.-str.
Camp Beamen	Sept. 26	6.00 a. m.	20.5	26							W.	Cu.-str.
	Sept. 26	9.30 a. m.	20.53	50							W.	Cu.-str.
Photograph Station on ridge west fork Black's Fork.	Sept. 26	9.45 a. m.	20.51	53				10,334			S. W.	Clear.
Calcareous sandstone bluffs, west fork Black's Fork.	Sept. 26	10.30 a. m.	20.45	52				10,411			N. W.	Cir.-cu.
Ridge north of source of east fork of Bear River.	Sept. 26	11.30 a. m.	20.02	48				10,974			N. W.	Cir.-cu.
Base of calcareous sandstone, source east fork Bear River.	Sept. 26	12.30 p. m.	20.05	48				10,347			N. W.	Cir.-cu.
Camp on Divide of west fork Black's Fork, and east fork Bear River.	Sept. 26	2.00 p. m.	20.05	44				10,903			N. W.	Cir.-cu.
First quartzite needle on divide south of camp.	Sept. 26	4.00 p. m.	19.7	44				11,398				Cu.-str. and nimbus.
Second and third quartzite needles on divide south of camp.	Sept. 26	4.30 p. m.	19.62	44				11,505				Cu.-str. and nimbus.
Fourth quartzite needle on divide south of camp	Sept. 26	4.40 p. m.	19.52	42				11,640				Cu.-str. and nimbus.
Quartzite plateau	Sept. 26	4.50 p. m.	19.48	42				11,694				Cu.-str. and nimbus.
Depression in divide south of plateau	Sept. 26	5.00 p. m.	19.62	40				11,505				Cu.-str. and nimbus.
Fifth quartzite needle south of camp	Sept. 26	5.15 p. m.	19.56	40				11,586				Cu.-str. and nimbus.
Sixth quartzite needle south of camp	Sept. 26	5.30 p. m.	19.55	40				11,599				Cu.-str. and nimbus.
Camp on divide west fork Black's Fork and east fork Bear River.	Sept. 27	6.00 a. m.	19.9	26				11,066			N. W.	Cir.-str.
	Sept. 27	7.45 a. m.	20.0	44							N. W.	Cu.-str.
Pine line east fork Bear River	Sept. 27	9.15 a. m.	21.25	50				9,390			N. W.	Cir.-str.
Quaking-asp line	Sept. 27	10.30 a. m.	21.45	52				9,103			N. W.	Cir.-str.
Sage-bush line	Sept. 27	11.00 a. m.	21.75	60				8,768			N. W.	Cir.-str.
Junction of west fork and east fork of Bear River.	Sept. 27	11.45 a. m.	22.14	68				8,291			N. W.	Cir.-str.
Dinner camp below the junction	Sept. 27	2.00 p. m.	22.32	72				8,073			N. W.	Cir.-str.
Southeast corner Bear River basin	Sept. 27	3.30 p. m.	22.52	74				7,833			N. W.	Cir.-str.
Sulphur Creek at point of entrance of basin	Sept. 27	4.00 p. m.	22.82	52				7,476			N. W.	Cir.-cu. in southeast horizon.
Camp on Sulphur Creek, sixty rods south Lime Ridge.	Sept. 27	5.10 p. m.	22.86	50				7,376			N. W.	Cir.-cu. in southeast horizon.
	Sept. 28	6.00 a. m.	22.95	33								Cir.-str. south horizon.
Bluff west of Piedmont	Sept. 28	9.15 a. m.	23.04	48				7,217				Cir.-cu.
First bluff east of Piedmont	Sept. 28	9.30 a. m.	22.8	54				7,500				Cir.-cu.
Divide between Bear River and Black's Fork	Sept. 28	9.45 a. m.	22.68	56				7,642				Cir.-cu.
Piedmont railroad station	Sept. 28	9.20 a. m.	23.34	50				6,867				Cir.-cu.
Old ford southwest Bridger Butte	Sept. 28	11.00 a. m.	22.98	62				7,391				Cir.-cu.
Base of Bridger Butte, southwest point	Sept. 28	11.30 a. m.	23.06	66				7,194				Cir.-cu.
North and south ends of Bridger Butte	Sept. 28	11.55 a. m.	22.78	76				7,524				Cir.-cu.

Meteorological notes taken during the months of July, August, September, and October—Continued.

Point of observation.	Date.	Hour of day.	Barometric reading.	Fahrenheit. Ther. No. 1.	Ther. No. 2.	Ther. No. 4.		Approximate elevation.	Intermediate distance traveled.	Total distance traveled.	Direction of wind.	Clouds and general remarks.
Black's Fork, Fort Bridger. (Camp)	Sept. 28	3. 00 p. m.	23. 42	66								Cir.-cu.
	Sept. 29	6. 30 a. m.	23. 42	33	33	33	34				S. W.	Cir.-str.
	Sept. 29	2. 30 p. m.	23. 42	76	76	74	76				S. W.	Cir.-str.
	Sept. 29	6. 00 p. m.	23. 42	62	62	60	60				S. W.	Cir.-str.
	Sept. 30	6. 15 a. m.	23. 42	30	30	28	30				S. W.	Clear.
	Sept. 30	9. 00 a. m.	23. 42	58	58	56	55				S. W.	Clear.
	Sept. 30	3. 00 p. m.	23. 38	76	76	75	75				S. W.	Clear.
	Oct. 1	6. 30 a. m.	23. 42	42	42	40	41				S. W.	Cir.-str. on the horizon.
Smith's Fork, ford	Oct. 1	9. 45 a. m.	23. 42				50	6, 775			S. W.	Cir.-cu.
Cottonwood Creek, ford	Oct. 1	11. 00 a. m.	23. 56				58	6, 611			S. W.	Cir.-cu. in southwest.
Foot of divide between Smith's and Henry's Forks.	Oct. 1	12. 00 m.	23. 54				58	6, 636			S. W.	Cir.-str. and cir.-cu.
Top of first Mauvaises Terres Bluff	Oct. 1	12. 10 p. m.	23. 4				58	6, 798			S. W.	Cir.-str. and cir.-cu.
Sage Creek, ford	Oct. 1	12. 45 p. m.	23. 38				58	6, 821			S. W.	Cir.-str. and cir.-cu.
Cottonwood Creek, ford	Oct. 1	2. 00 p. m.	23. 18				65	7, 053			S. W.	Cir.-cu.
Base of hill divide	Oct. 1	3. 45 p. m.	22. 78				60	7, 524			S. W.	Cir.-cu.
Divide between Henry's and Smith's Forks	Oct. 1	4. 00 p. m.	22. 68	59	59	57	59	7, 642			S. W.	Cir.-cu.
Henry's Fork. (Camp)	Oct. 1	6. 30 p. m.	22. 84	59	59	56	57	7, 390	28. 92	483. 177		Hazy.
	Oct. 2	6. 30 a. m.	22. 9	28	28	25	27					Hazy.
	Oct. 2	9. 00 a. m.	22. 94	62	62	60	61					Hazy.
Point of departure from Henry's Fork	Oct. 2	10. 30 a. m.	22. 25				65	8, 158				Hazy.
On the foot hills, Uinta Mountains	Oct. 2	12. 30 p. m.	21. 42				68	9, 177				Hazy.
Sandstone Ridge, north point reading	Oct. 2	2. 15 p. m.	20. 79				68	9, 973				Hazy.
Sandstone Ridge, south point reading	Oct. 2	2. 45 p. m.	20. 78				68	9, 986				Hazy.
Valley south Sandstone Ridge	Oct. 2	3. 15 p. m.	21. 2				68	9, 453				Hazy.
Camp northeast Gilbert's Peak, near Limestone Ridge, in a beautiful park.	Oct. 2	6. 00 p. m.	20. 9				49	9, 833				Hazy.
	Oct. 3	6. 00 a. m.	20. 9				29				S. E.	Cir. in northeast.
Extreme limit of arborescent vegetation	Oct. 3	9. 00 a. m.	19. 92				48	11, 106			S. E.	Cu.-str.
Point of access with horses under Gilbert's P'k.	Oct. 3	10. 00 a. m.	19. 06				52	12, 265			S. E.	Cir.-str.
Gilbert's Peak	Oct. 3	10. 30 a. m.	18. 40				40	13, 182			S. E.	Cir.-str.
	Oct. 3	10. 45 a. m.	18. 40				40				S. E.	Cir.-str.
	Oct. 3	11. 00 a. m.	18. 40				38				S. E.	Cir.-str.
Point of access with horses, 2d reading	Oct. 3	11. 30 a. m.	19. 02				46	12, 311			S. E.	Cir.-str.
Base of Gilbert's Peak, north side	Oct. 3	12. 00 m.	19. 65				58	12, 566			S. E.	Cir.-str.
First lake, source east fork Henry's Fork	Oct. 3	12. 30 p. m.	20. 00				58	11, 000				Cu.-str.
Henry's Fork. (Camp, 2d observation)	Oct. 3	6. 00 p. m.	22. 74		56	56	56	7, 615				Cu.-str.
	Oct. 4	6. 30 a. m.	22. 65		34	32	34					Cu.-str.
	Oct. 4	8. 30 a. m.	22. 72		66	64	64					Cu.-str.

Mauvaises Terres, ridge, northeast. (Camp)	Oct.	4	10. 00 a. m.	21. 90				56	8, 583				Cu.-str. in the north.
Henry's Fork	Oct.	4	10. 15 a. m.	21. 90				56	8, 583				Cu.-str.
Crossing Henry's Fork below junction east fork	Oct.	4	11. 30 a. m.	23. 29				68	6, 925				Cu.-str.
First terrace	Oct.	4	11. 45 a. m.	23. 22				68	7, 007				Cu.-str-
Second terrace	Oct.	4	12. 30 p. m.	23. 02				60	7, 241				Cu.-str.
Second terrace, lower down the fork	Oct.	4	1. 00 p. m.	22. 98				60	7, 391				Cu.-str.
Second terrace, still lower down the fork	Oct.	4	1. 30 p. m.	23. 12		63	62	62	7, 123				Cu.-str.
Henry's Fork on the bottom. (Camp Turnbull)	Oct.	4	3. 00 p. m.	23. 43		63	62	62		23. 6	506. 777	N. W.	Cir.-str. and Cir.-cu.
	Oct.	4	6. 00 p. m.	23. 59		46	45	45	6, 593			N. W.	Cir.-str.
	Oct.	5	6. 00 a. m.	23. 59		19	19	16				N. W.	Cir.-str.
	Oct.	5	9. 00 a. m.	23. 70				48				N. W.	Cir.-str.
Green River below junction Henry's Fork	Oct.	5	6. 30 p. m.	24. 52		52	50	51	5, 528	21. 88	528. 657	N. W.	Cir.-str.
	Oct.	6	6. 30 a. m.	24. 52		28	26	27				N. W.	Cir.-str.
First terrace above Henry's Fork	Oct.	6	9. 00 a. m.	24. 42				53	5, 639			N. W.	Cir.-str.
Second terrace above Henry's Fork	Oct.	6	9. 10 a. m.	24. 37				53	5, 695			N. W.	Cir.-str.
Third terrace above Henry's Fork	Oct.	6	9. 15 a. m.	24. 32				53	5, 751			N. W.	Cir.-cu.
Fourth terrace above Henry's Fork	Oct.	6	9. 20 a. m.	24. 26				53	5, 818				Cir.-cu.
Sandstone Ridge	Oct.	6	9. 25 a. m.	24. 18				53	5, 908				Cir.-cu.
Near junction Henry's Fork Green River	Oct.	6	11. 30 a. m.	24. 48				53	5, 573				Cir.-cu.
Highest point of ridge west of Green River	Oct.	6	12. 30 p. m.	23. 25				60	6, 972				Cir.-cu.
Henry's Fork, one mile from junction, on the bottom. (Camp Stevenson.)	Oct.	6	6. 00 p. m.	24. 18		63	62	63				N. W.	Cir.-cu.
	Oct.	7	6. 30 a. m.	24. 18		34	33	35	5, 874	1. 00	529. 675	N. W.	Cir.-str. and nimbus.
	Oct.	7	3. 00 p. m.	24. 18		63	62	62				N. W.	Cir.-str.
	Oct.	7	6. 00 p. m.	24. 18		56	56	58				N. W.	Cir.-str.
	Oct.	8	6. 30 a. m.	24. 30		29	28	29				N. W.	Cir.-str.
On the Indian trail ford of Green River	Oct.	8	8. 30 a. m.	24. 40				50	5, 662				Cir. and cir.-cu.
First ridge on trail east of Green River	Oct.	8	9. 30 a. m.	23. 52				52	6 659				Cir.-cu.
Valley	Oct.	8	10. 30 a. m.	23. 92				52	6, 201				Cir.-cu.
Second ridge east of Green River	Oct.	8	10. 40 a. m.	23. 68				52	6, 475				Cir.-cu.
Valley	Oct.	8	10. 50 a. m.	23. 84				52	6, 293				Cir.-cu.
Valley, second hollow	Oct.	8	11. 00 a. m.	23. 88				52	6, 247				Cir.-cu.
Valley, third hollow	Oct.	8	11. 15 a. m.	23. 98				52	6, 134				Cir.-cu.
Third ridge east of Green River	Oct.	8	11. 20 a. m.	23. 84				52	6, 293				Cir.-cu.
Valley	Oct.	8	11. 30 a. m.	24. 20				55	5, 886				Cir.-cu.
Fourth ridge east of Green River	Oct.	8	11. 45 a. m.	23. 86				52	6, 270				Cir.-cu.
Valley	Oct.	8	12. 15 p. m.	24. 18				52	5, 9[illegible]8				Cir.-cu.
Valley on the Green River	Oct.	8	12. 30 p. m.	24. 45				52	5, 606				Cir.-cu.
First bluff above Green River	Oct.	8	1. 00 p. m.	24. 54				52	5, 506				Cir.-cu.
Second bluff above Green River	Oct.	8	1. 05 p. m.	24. 51				52	5, 539				Cir.-cu.
On bluff above second valley on Green River	Oct.	8	1. 15 p. m.	24. 58				60	5, 462				Cir.-cu.
On Green River	Oct.	8	1. 30 p. m.	24. 70				60	5, 329				Cir.-cu.
On ravine rise	Oct.	8	2. 00 p. m.	24. 52				60	5, 528				Cir.-cu.
In ravine	Oct.	8	2. 05 p. m.	24. 55				60	5. 495				
On divide	Oct.	8	2. 15 p. m.	24. 08				60	6, 021			N. W.	Cir.-str. a little.
Red Creek ford	Oct.	8	2. 45 p. m.	24. 54				62	5, 506				Cir.-str.
Ridge above Creek	Oct.	8	2. 55 p. m.	24. 54				62	5, 751				Cir.-str.
Henry's Fork road and Indian Trail Junction, Green River.	Oct.	8	3. 30 p. m.	24. 66				62	5, 373				Cir.-str.
First ridge	Oct.	8	3. 40 p. m.	24. 07				65	5, 329				Cir.-str.
Second ridge	Oct.	8	3. 50 p. m.	24. 65				65	5, 384				Cir.-str.
Third ridge	Oct.	8	3. 55 p. m.	24. 58				65	5, 462				Cir.-str.
Fourth ridge	Oct.	8	4. 00 p. m.	24. 42				44	5, 639			S. W.	Cir.-str.

Meteorological reports taken during the months of July, August, September, and October—Continued.

Point of observation.	Date.	Hour of day.	Barometric reading.	Fahrenheit. Ther. No. 1.	Ther. No. 2.	Ther. No. 4.		Approximate elevation.	Intermediate distance traveled.	Total distance traveled.	Direction of wind.	Clouds and general remarks.
Green River, on the bottom, Brown's Hole. (Camp.)	Oct. 8	7.45 p. m.	24.84				38	5,186			S. W.	Cir.-str.
	Oct. 9	6.00 a. m.	24.82				20				S. W.	Cir.-str.
Green River Cañon, southeast end Brown's Hole	Oct. 9	9.00 a. m.	24.98				44	6,134			S. W.	Cir.-str.
Top of first White Mauvaises Bluff	Oct. 9	9.45 a. m.	24.62				50	5,418			S. W.	Cir.-str.
Top of second White Mauvaises Bluff	Oct. 9	10.15 a. m.	24.52				50	5,528			S. W.	Cir.-str.
Valley	Oct. 9	10.50 a. m.	24.58				50	5,462			S. W.	Cir.-str.
Indian Trail and Henry's Fork Road Junction, Green River.	Oct. 9	11.00 a. m.	24.62				58	5,417			S. W.	Cir.-str.
Red Creek, crossing Henry's Fork road	Oct. 9	12.00 m.	24.38				58	5,684			S. W.	Cir.-cu.
Dinner Camp, mouth Red Creek Cañon	Oct. 9	3.00 p. m.	24.19				66	5,897			S. W.	Cu.-str. and nimbus; rain.
Camp on Henry's Fork road, two miles west of Red Creek.	Oct. 9	8.00 p. m.	23.54				45	6,636			N. W.	Cir. Lightning at 7 o'clock, p. m., with heavy cu. str.
	Oct. 10	6.15 a. m.	23.54				31				N. W.	Cu-str.
Quartz Mountain, south camp	Oct. 10	9.00 a. m.	22.62				50	7,714			N. W.	Cir.-str.
Quartz Mountain, capped with sandstone	Oct. 10	9.30 a. m.	22.32				50	8,073			N. W.	Hazy.
Camp on Henry's Fork, west of Red Creek	Oct. 10	10.30 a. m.	23.54				66				N. W.	Hazy.
Henry's Fork road, white ridge	Oct. 10	11.30 a. m.	23.18				66	7,053			N. W.	Cu. in the north.
Green River, crossing Indian trail	Oct. 10	3.15 p. m.	24.12				66	5,976			N. W.	Cir.-cu.
Camp Stevenson	Oct. 10	6.00 p. m.	24.08		54	52	55	6,021			N. W.	Cir.-cu.
Camp Stevenson	Oct. 11	6.30 a. m.	24.22		23	22	18	5,863			S. W.	Cir.-str. in west.
Green River, on the bottom. (Camp)	Oct. 11	4.00 p. m.	24.25		62	62	62	5,852	19.945	549.602	N. W.	Hazy.
	Oct. 11	11.00 p. m.	24.22		33	32	32				N. W.	Clear.
	Oct. 12	6.30 a. m.	24.22		23	21	23				N. W.	Clear.
First ridge above second ford	Oct. 12	8.30 a. m.	24.12				44	5,976				Cir.-str.
Second ridge above second ford	Oct. 9	9.00 a. m.	23.98				44	6,134			N. W.	Cir.-cu.
Third ridge above second ford	Oct. 12	9.30 a. m.	24.14				44	5,953			N. W.	Cir.-str.
Fourth ridge above second ford	Oct. 12	11.00 a. m.	23.96				44	6,156			N. W.	Cir.-str.
Fifth ridge above second ford	Oct. 12	11.30 a. m.	23.62				44	6,544			N. W.	Cir.-str.
Black's Fork ford	Oct. 12	12.00 m.	24.08				48	6,021			N. W.	Cir.-str.
Green River ford, near junction Black's Fork	Oct. 12	12.05 p. m.	24.17				48	5,921			N. W.	Cir.-str.
Bluff above third ford	Oct. 12	1.30 p. m.	23.99				48	6,201			N. W.	Cir.-cu.
Valley	Oct. 12	2.30 p. m.	23.99				48	6,124			N. W.	Cir.-cu.
Bluff	Oct. 12	2.45 p. m.	23.72				48	6,430			N. W.	Cir.-cu.
Valley	Oct. 12	3.00 p. m.	24.09				48	6,009			N. W.	Cir.-cu.
Green River, on the bottom, East Green River City. (Camp.)	Oct. 12	11.45 p. m.	24.44		32	32	33	5,617	45	594.602		Clear.
	Oct. 13	7.00 a. m.	24.44		24	24	24				N. W.	Cir.-str.
Hill north of Castle Rock, Green River City	Oct. 13	9.30 a. m.	23.82				53	6,316			N. W.	Cir.-str.
Top of Castle Rock	Oct. 13	9.40 a. m.	23.92				53	6,201			N. W.	Cir.-str.

Base of turret, north side Castle Rock	Oct.	13	9.45 a. m.	23.98				53	6,134			N. W.	Cir.-str.
White beds	Oct.	13	9.55 a. m.	24.02				53	6,089			N. W.	Cir.-str.
Green River Railroad ford	Oct.	13	10.00 a. m.	24.42		60	59	59	5,639			N. W.	Cir.-str.
Green River City. (Camp.)	Oct.	13	2.00 p. m.	24.39		60	58	60				N. W.	Cir.-str.
Highest point plateau, southwest Green River City.	Oct.	13	3.00 p. m.	23.82				60	6,315			N. W.	Cir.-cu.
Green River camp, opposite Green River City	Oct.	13	6.00 p. m.	24.28		47	46	47	5,863			N. W.	Cu.-str.
	Oct.	14	6.30 a. m.	24.16		34	33	34				N. W.	Cir.
Rock Springs Stage station. (Camp)	Oct.	14	1.30 p. m.	23.69		68	67	66	6,341	17.246	611.848	N. W.	Cir.-str. Wind very violent.
	Oct.	14	8.00 p. m.	23.80		48	48	50				N. W.	Cir. and cu.-str. Wind very violent.
	Oct.	15	6.00 a. m.	23.90		28	26	28				N. W.	Cu.-str.
Salt Wells, Union Pacific Railroad station	Oct.	15	11.30 a. m.	23.82				36	6,316			N. W.	Cu.-str.
Bitter Creek, Point of Rocks, Union Pacific Railroad station.	Oct.	15	2.00 p. m.	23.69				36	6,464			N. W.	Cu.-str.
Bitter Creek, on the bottom	Oct.	15	3.30 p. m.	23.72		38	39	40	6,430	26.913	638.761	N. W.	Cu. and cir.-cu.
One mile above the Point of Rocks station	Oct.	15	8.00 p. m.	23.79		25	24	25	6,367			N. W.	Clear.
	Oct.	16	6.00 a. m.	23.76		22	20	21				N. W.	Cir.-str.
Big Pond Stage station	Oct.	16	4.00 p. m.	23.56		39	37	39	6,542	22.165	660.926	N. W.	Cu.-str.
	Oct.	17	3.30 a. m.	23.68		8	8	9				E.	Clear.
Barrel Springs	Oct.	17	3.30 p. m.	23.78		52	50	51	6,414				Clear.
	Oct.	17	7.00 p. m.	23.80		32	33	29		28.118	689.044		Clear.
	Oct.	18	6.15 a. m.	23.62		14	13	14					Clear.
Bluff on the road	Oct.	18	11.00 a. m.	23.91				60	6,213			N. W.	Cir.-cu. around the horizon.
Bluff on the road	Oct.	18	11.45 a. m.	23.78				60	6,361			N. W.	Cir.-cu. around the horizon.
Valley, Duck Pond station	Oct.	18	11.50 a. m.	23.85				55	6,281			N. W.	Cir.-cu. around the horizon.
Bluff	Oct.	18	12.15 p. m.	23.74				55	6,407			N. W.	Cir.-cu. around the horizon.
Bluff	Oct.	18	1.00 p. m.	23.48				55	6,705			N. W.	Cir.-cu. around the horizon.
West side of valley	Oct.	18	1.15 p. m.	23.66				55	6,498			N. W.	Cir.-cu. around the horizon.
East side of valley	Oct.	18	1.40 p. m.	23.71				55	6,441			N. W.	Cir.-cu. around the horizon.
Ridge south of Clay Mounds	Oct.	18	1.45 p. m.	23.66				55	6,498			N. W.	Cir.-cu. around the horizon.
Valley	Oct.	18	2.15 p. m.	23.78				55	6,361			N. W.	Cir.-cu. around the horizon.
Branch of Muddy ford; Muddy, on the bottom, near Washakie Stage station.	Oct.	18	3.00 p. m.	23.70				48	6,453			N. W.	Cir.-str. around the horizon.
	Oct.	18	4.00 p. m.	23.72		56	54	55		20.207	709.251	N. W.	Cir.-str. around the horizon.
	Oct.	19	6.15 a. m.	23.80		22	20	20	6,323			N. W.	Clear.
	Oct.	19	9.00 a. m.	23.92				44					Clear.
Rise on the road opposite coal outcrop	Oct.	19	9.15 a. m.	23.88				44	6,247				Clear.
Ridge above coal outcrop	Oct.	19	9.20 a. m.	23.84				44	6,293				Clear.
First high ridge west of Muddy ford	Oct.	19	10.45 a. m.	23.53				44	6,646			S. E.	Cir.-str.
Muddy Creek ford	Oct.	19	11.00 a. m.	23.68				44	6,475			S. E.	Cir.-str.
Sulphur Springs, stage station. (Camp)	Oct.	19	1.00 p. m.	23.61		54	53	53		10.065	719.316	S. E.	Cir.-str.
	Oct.	19	4.15 p. m.	23.56		55	54	55	6,651			S. E.	Cir.-str.
	Oct.	19	6.00 p. m.	23.52		47	44	46				S. E.	Cir.-str.
	Oct.	20	6.30 a. m.	23.42		20	18	20				S. W.	Clear.
Road ridge a quarter of a mile from camp	Oct.	20	9.00 a. m.	23.52				45	6,659			S. W.	Cu.-str.
Tenth ridge below top of hill northeast camp	Oct.	20	9.20 a. m.	23.05				46	7,205			S. W.	Cu.-str.
Ninth ridge below top of hill northeast camp	Oct.	20	9.25 a. m.	23.02				46	7,241			S. W.	Cu.-str.
Eighth ridge below top of hill northeast camp	Oct.	20	9.30 a. m.	22.94				46	7,335			S. W.	Cu.-str.
Seventh	Oct.	20	9.35 a. m.	22.87				46	7,417			S. W.	Cu.-str.
Sixth	Oct.	20	9.40 a. m.	22.81				46	7,488			S. W.	Cu.-str.
Fifth	Oct.	20	9.45 a. m.	22.79				46	7,512			S. W.	Cu.-str.
Fourth	Oct.	20	9.50 a. m.	22.74				46	7,511			S. W.	Cu.-str.
Third	Oct.	20	10.00 a. m.	22.73				46	7,583			S. W.	Cu.-str.

Meteorological reports taken during the months of July, August, September, and October—Continued.

Point of observation.	Date.	Hour of day.	Barometric reading.	Fahrenheit. Ther. No. 1.	Ther. No. 2.	Ther. No. 4.		Approximate elevation.	Intermediate distance traveled.	Total distance traveled.	Direction of wind.	Clouds and general remarks.
Second	Oct. 20	10. 5 a. m.	22. 72				46	7, 595			S. W.	Cu.-str.
First	Oct. 20	10. 10 a. m.	22. 66				46	7, 666			S. W.	Cu.-str.
Top of hill northeast camp, Sulphur Springs	Oct. 20	10. 15 a. m.	22. 64				52	7, 690			S. W.	Cu.-str.
Old ford of Muddy	Oct. 20	11. 00 a. m.	23. 46				56	6, 728			S. W.	Cu.-str.
First ridge in road beyond the ford	Oct. 20	11. 10 a. m.	23. 17				56	7, 065			S. W.	Cu.-str.
First ridge in valley north of creek	Oct. 20	12. 00 m.	22. 91				56	7, 370			S. W.	Cu.-str.
Second ridge in the pass	Oct. 20	12. 15 p. m.	22. 91				56	7, 370			S. W.	Cir.-cu.
Third ridge in the pass	Oct. 20	12. 25 p. m.	22. 91				56	7, 370			S. W.	Cir.-cu.
Valley	Oct. 20	12. 30 p. m.	22. 94				56	7, 335			S. W.	Cir.-cu.
Fourth ridge Bridger's Pass	Oct. 20	12. 35 p. m.	22. 84				56	7, 453			S. W.	Cu. and cu.-str.
Bridger's Pass Stage Station	Oct. 20	12. 40 p. m.	22. 88				56	7, 405			S. W.	Cu. and cu.-str.
First ridge beyond Bridger's Pass Station	Oct. 20	12. 45 p. m.	22. 80				56	7, 500			S. W.	Cir.-cu
Second ridge beyond Bridger's Pass Station	Oct. 20	12. 50 p. m.	22. 80				56	7, 500			S. W.	Cir.-cu.
Third ridge beyond Bridger's Pass Station	Oct. 20	12. 55 p. m.	22. 76				56	7, 547			S. W.	Cir.-cu.
Fifth ridge beyond Bridger's Pass Station	Oct. 20	1. 00 p. m.	22. 74				56	7, 571			S. W.	Cir.-cu.
Sixth ridge beyond Bridger's Pass Station	Oct. 20	1. 10 p. m.	22. 72				56	7, 595			S. W.	Cir.-cu.
Atlantic and Pacific divide	Oct. 20	1. 20 p. m.	22. 74				56	7, 571			S. W.	Cir.-str.
Bluff below Atlantic and Pacific divide	Oct. 20	1. 40 p. m.	22. 78				56	7, 524			S. W.	Cu.-str.
West bluff above Red Birch Valley	Oct. 20	2. 20 p. m.	22. 92				56	7, 338			S. W.	Cu.-str.
Red Birch Valley	Oct. 20	2. 25 p. m.	22. 98				57	7, 288			S. W.	Cu.-str.
East bluff above Red Birch Valley	Oct. 20	2. 45 p. m.	22. 84				57	7, 453			S. W.	Cu.-str.
Quaking Asp Springs. (Camp)	Oct. 20	3. 00 p. m.	22. 90		57	57	57	7, 388	15. 348	734. 664	S. W.	Cu.-str.
	Oct. 21	6. 30 a. m.	22. 86		37	36	57				S. W.	Cu.-str. in the east.
	Oct. 21	8. 00 a. m.	22. 90				44				S. E.	Cir.-str.
On the peak southeast Quaking Asp Springs	Oct. 21	9. 00 a. m.	22. 10				45	8, 340			S. E.	Cir.-str.
On the peak east Quaking Asp Springs	Oct. 21	9. 10 a. m.	22. 02				46	8, 437			S. E.	Cu.-str.
Plateau	Oct. 21	11. 30 a. m.	23. 02				46	7, 240			S. E.	Cu.-str.
Creek ford	Oct. 21	12. 15 p. m.	23. 28				49	6, 937			S. E.	Cu.-str.
Sage Creek ford	Oct. 21	2. 00 p. m.	23. 46				49	6, 728			S. E.	Cu.-str.
Highest ridge between Sage Creek and North Platte River.	Oct. 21	2. 30 p. m.	23. 32				49	6, 890			S. E.	Cu.-str.
North Platte River ford. (Camp Carrington)	Oct. 21	5. 00 p. m.	23. 42		50	49	50		23. 182	757. 846	S. E.	Cu str.
	Oct. 22	7. 15 p. m.	23. 32		42	43	42	6, 877			S. W.	Cir.-cu. and cu.-str.
	Oct. 22	3. 00 p. m.	23. 22		61	50	61				S. W.	Clear.
	Oct. 23	7. 00 a. m.	23. 28		42	43	42				S. W.	Cu.-str.
	Oct. 23	9. 00 a. m.	23. 42				48				S. W.	Cu.-str.
Bluff east of North Platte River, on the road	Oct. 23	10. 00 a. m.	23. 15				48	7, 088			S. W.	Cu.-str.
Plateau west of Pass Creek	Oct. 23	12. 30 p. m.	23. 15				52	7, 088			S. W.	Cu.-str.

Pass Creek ford. (Camp)	Oct.	23	3.00 p. m.	23.21		58	57	58	6,862	14.939	772.785	S. W.	Cir.-str.
	Oct.	24	7.00 a. m.	23.48		38	36	38					Cir.-str.
Third ford, Rattlesnake Creek	Oct.	24	10.00 a. m.	23.21				42	7,019			N. W.	Cu.-str.
Divide, Rattlesnake Pass	Oct.	24	10.30 a. m.	22.94				42	7,335			N. W.	Cu.-str.
Sutler's store, old Fort Halleck	Oct.	24	12.00 m.	23.08				42	7,170			N. W.	Cu.-str.
Medicine Bow Creek on the bottom, near the bridge. (Camp Hayden.)	Oct.	24	2.00 p. m.	23.12		43	42	43		17.983	790.768	S. W.	Cu.-str. and nimbus. Rain.
	Oct.	25	7.00 a. m.	23.08		40	38	40				S. W.	Cu.-str. Cir.-cu. Heavy rain the night.
	Oct.	25	9.30 a. m.	23.10		45	44	45	7,152			S. W.	Nimbus. Rain.
	Oct.	25	10.30 a. m.	23.08				48				S. W.	Cu.-str.
First bluff east of bridge, Medicine Bow Creek	Oct.	25	10.45 a. m.	23.98				48	7,288			S. W.	Cu.-str.
Bluff west of Wagon Hound Creek	Oct.	25	11.30 a. m.	22.92				48	7,358			S. W.	Nimbus. Rain.
Wagon Hound Creek, ford	Oct.	25	11.45 a. m.	23.08				48	7,170			S. W.	Nimbus. Rain.
Bluff east of Wagon Hound Creek	Oct.	25	12.00 m.	22.84				48	7,453			S. W.	Nimbus. Rain.
Do	Oct.	25	1.30 p. m.	22.74				48	7,571			S. W.	Cu.-str. and nimbus.
Rock Creek bottom, near the bridge. (Camp)	Oct.	25	4.00 p. m.	22.60		52	50	52		14.362	805.130	S. W.	Cu.-str.
	Oct.	26	7.15 a. m.	22.46		36	34	36	7,852			S. W.	Cu.-str.
	Oct.	26	9.00 a. m.	22.52		42	42	42				S. W.	Cu.-str. and nimbus.
Little Laramie River stage station. (Camp)	Oct.	26	3.00 p. m.	22.99		48	47	48		23.955	829.085	S. W.	Cu.-str. and nimbus.
	Oct.	27	7.00 a. m.	23.10		31	32	29	7,143			S. E.	Cu.-str. in the west.
	Oct.	27	8.30 a. m.	23.22				44				S. W.	Cu.-str.
Big Laramie River west of Sanders's Station, Fort Sanders. (Camp.)	Oct.	27	1.30 p. m.	23.29		52	50	52		17.572	846.657	S. W.	Cir.-cu.
	Oct.	28	7.30 a. m.	23.38		22	20	22	6,899				Cir.-cu.
	Oct.	28	2.30 p. m.	23.38		51	50	51				S. E.	Cu.
	Oct.	29	7.30 a. m.	23.20		27	28	27					Cir.-cu. and cu.-str.
Camp at Fort Sanders	Oct.	29	9.45 a. m.	23.28				46	6,937			N. W.	Cir.-cu. in eastern horizon.
Foot of abrupt ascent from the plain	Oct.	29	12.00 m.	22.98				46	7,288			N. W.	Cir.-cu. in eastern horizon.
First ridge	Oct.	29	1.00 p. m.	22.10				46	8,340			N. W.	Cir.-cu. around the horizon.
Summit ridge, Cheyenne Pass	Oct.	29	2.00 p. m.	21.95				46	8,523			N. W.	Cir.-cu. around the horizon.
Valley	Oct.	29	2.15 p. m.	22.12				46	8,315			N. W.	Cir.-cu. around the horizon.
Second summit ridge, Cheyenne Pass	Oct.	29	2.30 p. m.	21.95				46	8,523			N. W.	Cir.-cu. around the horizon.
Lodge Pole Creek. (Ford)	Oct.	29	3.00 p. m.	23.28				49	6,937			N. W.	Cu.-str. in the east.
Lodge Pole Creek. (Camp)	Oct.	29	6.00 p. m.	23.42		44	43	44	6,696	20.539	867.196		Clear.
	Oct.	30	7.15 p. m.	23.46		25	23	25					Clear.
	Oct.	30	8.00 p. m.	23.58				48					Clear.
Quartermaster's depot, Fort D. A. Russell, on the flat southeast of the sutler's store. (Camp.)	Oct.	30	3.00 p. m.	24.12		55	54	55	6,010	21.000	888.196	S. W.	Clear.
	Oct.	31	8.00 a. m.	24.15		39	38	39					Cu.-str.
	Nov.	1	7.00 a. m.	24.00		44	43	44				N. W.	Cu.-str. in the east and northeast.

GENERAL INDEX

PART I.

PART II.